SPECIAL COMETS ISSUE

Mars landscape once “drenched in water”

May 2004
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Cool comets

Everything you need to see two bright visitors

Will Bush’s space plan fly?

PAGE 48

Capture meteors in a flash

Sky test: 8-inch starter scope

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THESE ROCKS ON MARS reveal the presence of abundant water in the planet's past. See page 42.

COMET HALE-BOPP — a great comet by anyone's standards — sailed through the Milky Way in early March 1997. Its path took it near the glowing red North America Nebula in Cygnus. For more about great comets of years past, including beautiful photos, see page 36.

MEADE IS LEADING OPTICAL, MECHANICAL, AND ELECTRONIC INNOVATION

For over three decades, Meade Instruments has driven astronomical discovery through patented product innovations that have changed the way amateur astronomers view and photograph the night sky. Meade's engineering team (the largest in the industry) meticulously designs and engineers the highest quality optics, precision mechanics, and advanced electronics into every telescope we manufacture. We don't go to these lengths just to stay number one – we do it because astronomy is our passion! Buy a Meade and see the difference.

Suggested U.S. national mail-order retail prices for LX200GPS-SMT models:

Model	Price	LPI/Autostar Suite	UHTC Group	Shipping & Handling*
8" LX200GPS-SMT	$2195	Free ($149 value)	$175	$105
10" LX200GPS-SMT	$2745	Free ($149 value)	$235	$145
12" LX200GPS-SMT	$3595	Free ($149 value)	$295	$215
14" LX200GPS-SMT	$4995	Free ($149 value)	$350	$265
7" LX200GPS-SMT	$2695	Free ($149 value)	$150	$125

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- **LPI (Lunar Planetary Imager)**™ is an easy-to-use Meade Astrocam that delivers stunning image quality. Unlike webcams, LPI images are not compressed at the imager and contain all of the imager data. This lack of compression results in crisp, clear image resolution. Images can later be stored in a variety of popular formats. **MEADE EXCLUSIVE**
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* The Meade Ultra-High Transmission Coatings group must be ordered at the time of telescope purchase. The UHTC cannot be retrofitted.

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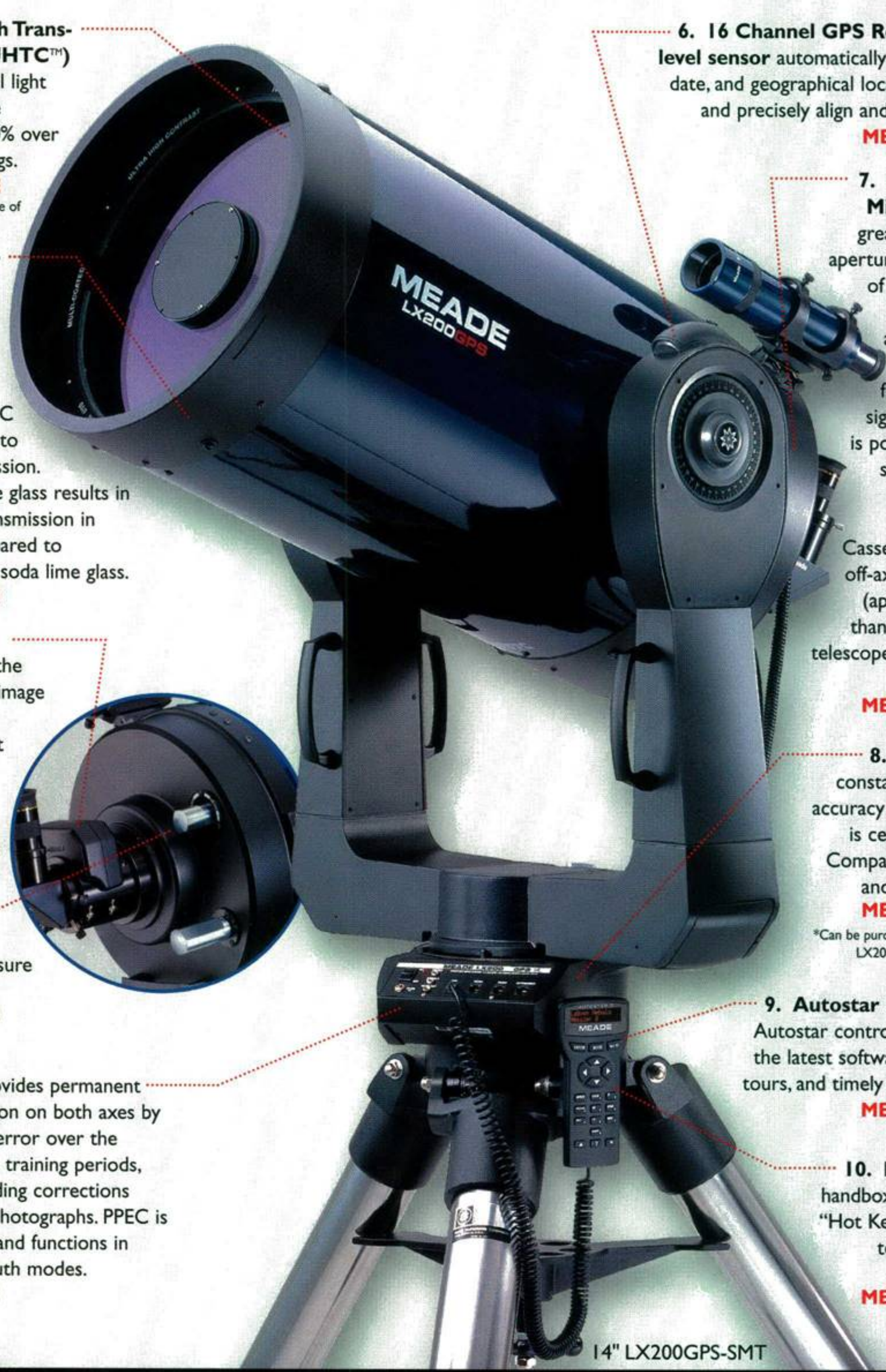
LX200GPS

10 REASONS WHY YOU SHOULD BUY A MEADE SCHMIDT-CASSEGRAIN:



1. Meade Ultra-High Transmission Coatings (UHTC™) Group* increases total light transmission and image brightness by nearly 20% over Meade standard coatings.
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*Available as an option only at time of purchase.

2. Optical System – Meade utilizes water white glass as standard equipment in all 8", 10", 12", and 14" Schmidt-Cassegrain corrector lenses (UHTC and standard coatings) to maximize light transmission. The use of water white glass results in an increase of light transmission in excess of 10% as compared to telescopes using green soda lime glass.
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9. Autostar Update keeps your Autostar controller up-to-date with the latest software upgrades, guided tours, and timely objects like comets.
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10. Meade Autostar II handbox controller features "Hot Keys" for quick access to a 145,000 celestial object database.
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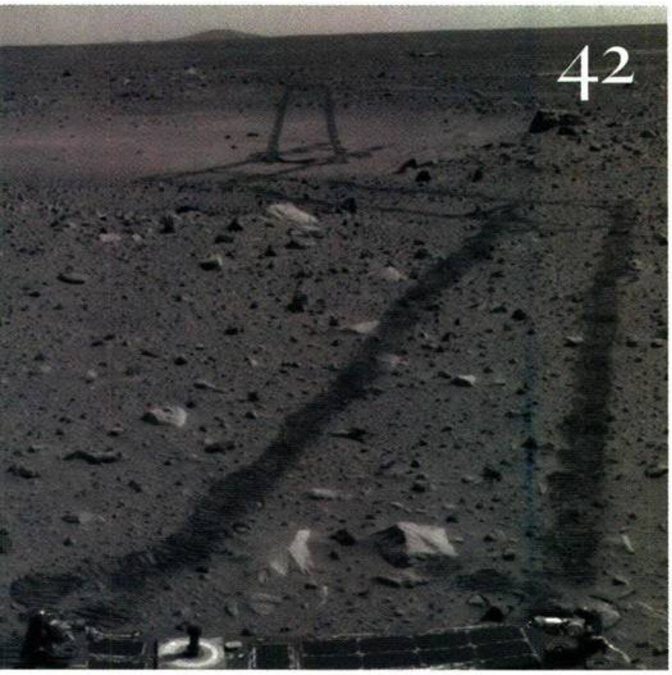
features



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COVER STORY

36 Great comets

Lots of comets come and go, but only a favored few have all the magic ingredients — the five key properties, to be precise — that make a comet *great.* RICHARD TALCOTT

PLANETARY SCIENCE

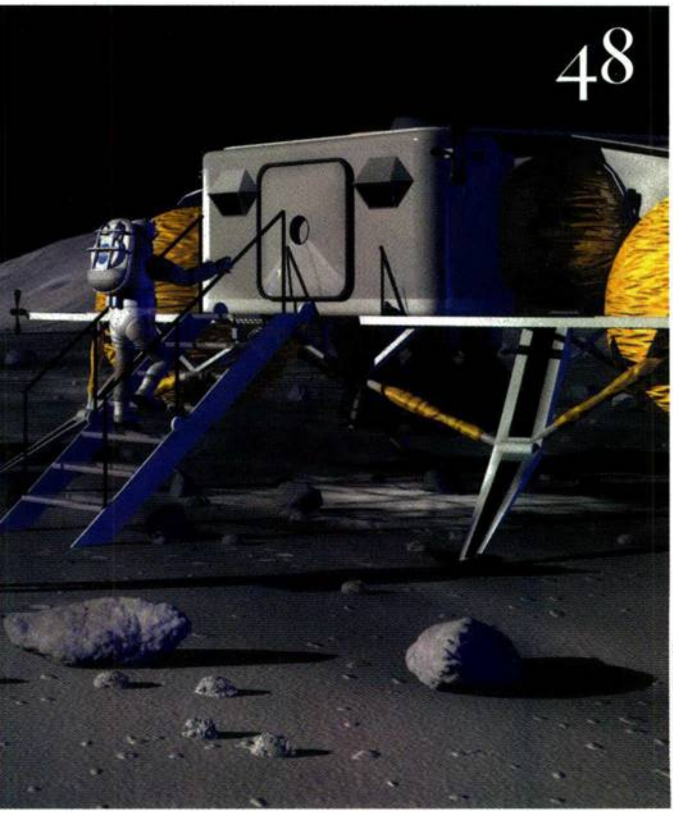
42 Opportunity at Meridiani

NASA's second Mars rover, Opportunity, landed at a site in Meridiani Planum that turned out to have been "drenched in water," as one scientist put it. It was once so wet and warm there as to be habitable. ROBERT BURNHAM

SPACE EXPLORATION

48 A new vision for space

U.S. president George W. Bush announced the boldest initiative in space exploration since Apollo: building a Moon base as a stepping-stone to Mars. Can it be done? Take a look at what's in store. FRANK SIETZEN, JR.



JOHN FRASSANITO & ASSOCIATES

SOLAR SYSTEM OBSERVING

70 A tale of two comets

Comets C/2002 T7 (LINEAR) and C/2001 Q4 (NEAT) should be at their brightest in May, providing wonderful views to observers around the globe. CHARLES S. MORRIS

IMAGING

76 All-sky fireball network

An interconnected group of all-sky cameras watches the sky 24 hours a day. The reason? The operators of this system are tracking brilliant meteors in the hope of actually recovering meteorites. JIM GAMBLE

TECHNIQUES

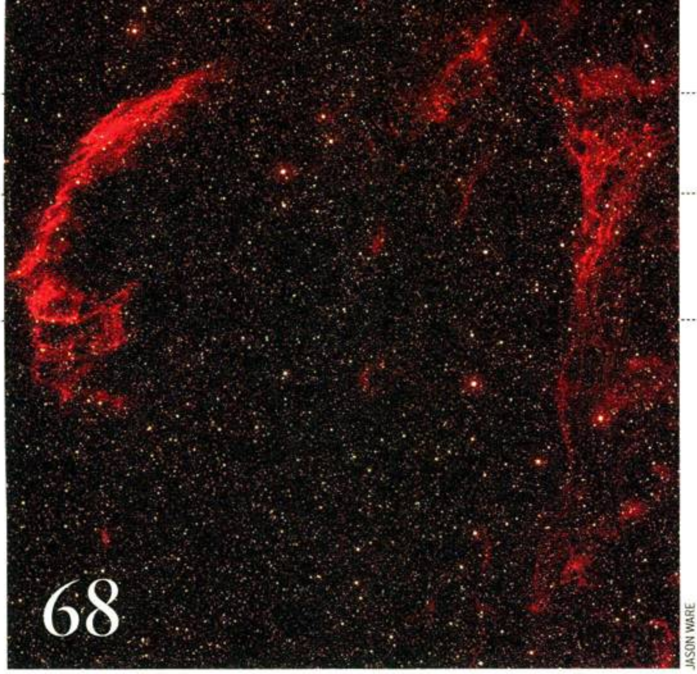
80 Robotic observing

Scour the sky while fast asleep. Too good to be true? Tenagra Observatories' computer-controlled telescopes let you catch supernovae while catching some shut-eye. TOM POLAKIS

TELESCOPE REVIEW

86 Orion's Atlas 8

A classic telescope design, a drive motor that follows the stars across the sky, and all the accessories you need to observe celestial objects make the new 8-inch reflector from Orion a winner. PHIL HARRINGTON



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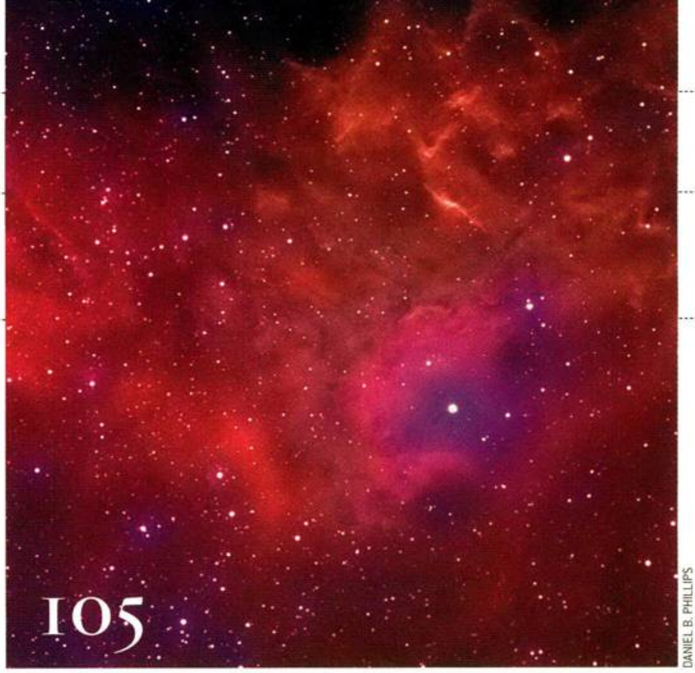

DANIEL B. PHILLIPS

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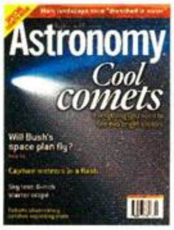


ON THE COVER

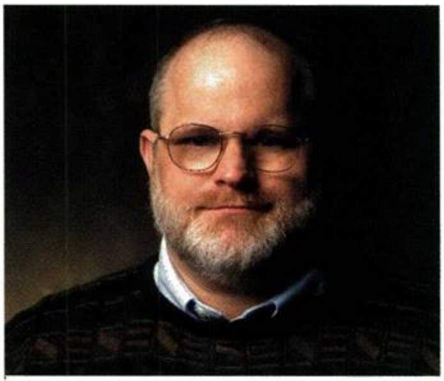
Comet Hale-Bopp (C/1995 O1) was the last great comet of the 20th century. At its peak in spring 1997, it shone brighter than magnitude 0 and exhibited a straight tail of bluish ionized gas as well as a curved tail of dust reflecting yellowish sunlight. This month sees two comets reach their peaks: Both C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) should be easy to spy with the naked eye. TONY AND DAPHNE HALLAS

BY DAVID J. EICHER

Astronomy Day

Each year amateurs rejoice on one day.

It is Astronomy Day, an event founded in 1973 by California astronomer Doug Berger and celebrated each year as a reminder of the beauty of the heavens. This year, the event will take place on April 24, a couple weeks after you receive this magazine. And *Astronomy* will make the day even better.



FRANK REDDY rejoins *Astronomy* after a hiatus of twenty years. *ASTRONOMY*: WILLIAM ZUBACK

Our magazine, in conjunction with Meade Instruments Corp., the world's largest telescope manufacturer, and a group of observatories and planetaria throughout the country, are joining forces to celebrate Astronomy Day. Experts at various sites will entertain visitors with a dazzling array of videos, images, presentations, models, and hands-on activities that will show off the mind-boggling events of deep space.

The venues are the Adler Planetarium in Chicago; Chabot Space and Science Center in Oakland, California; Lowell Observatory in Flagstaff, Arizona; the Miami Museum of Science and Planetarium in Florida; the Rose Center for Earth and Space in New York; and Gary Fujihara's spectacular AstroDay celebration in Hilo on the Big Island of Hawaii.

Each of these organizations will give away a Meade ETX-90AT telescope on that Saturday, April 24. All entries will be collected for a grand prize drawing. The lucky winner will receive a Meade 10-inch LX200GPS SmartMount Telescope with UHTC and the Autostar Suite. A state-of-the-art observing tool in itself, the telescope is also hand-signed by NASA astronaut and *Astronomy* Editorial Advisory Board member Buzz Aldrin. To learn more, visit www.astronomy.com.

I am also excited to let you know about an addition to *Astronomy*'s staff. Frank Reddy returns to the magazine as an associate editor after a twenty-year hiatus. Most of his energy will be focused on the magazine's web site. Frank served as an assistant editor in the early 1980s before writing educational materials, exhibit labels and audio-visual scripts for several museums. His growing interest in computers and the on-line world turned from hobby to livelihood, ultimately taking him to South Carolina to support field offices for a health insurance company.

Frank is the author of a variety of astronomically themed books, including *Discover Light and Sound, Rand McNally Children's Atlas of the Universe, Halley's Comet,* and, with coauthor Greg Walz-Chojnacki, *Celestial Delights: The Best Astronomical Events through 2010.*

Yours truly,

Dave Eicher
Editor

Astronomy
VoL. 32 No. 5

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Meade Model SN-8 8" f/4 Schmidt-Newtonian Telescope with standard-equipment Autostar Control System.

(below, left to right) 8" Model SC-8 Schmidt-Cassegrain; 5" Model AR-5 and 6" Model AR-6 Achromatic Refractors.

Meade Ultra-High Transmission Coatings (UHTC) Group: Available optionally at the time of telescope purchase, the UHTC group increases image brightness by about 20% over the visible spectrum.
SN-6, SN-EC – $85;
SN-8, SN-8EC – $125;
SN-10 – $150, SC-8 – $175

Packing & shipping charges in the 48 states:
SN-6, SN-6EC – $75;
SN-8, SN-8EC – $85;
SN-10 – $95;
SC-8 – $85;
AR-5, AR-5EC – $85;
AR-6 – $95

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Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for about 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

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- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

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8" LX90
Schmidt-Cassegrain
$1695

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; Autostar Suite with imager; operating instructions. **$1695. Ultra-High Transmission Coatings (UHTC) group** increases image brightness by about 20%: add **$175.** Packing & shipping in the 48 states: $95.

The Meade 8" LX90 is manufactured under U.S. Patent Nos. 6,304,376 and 6,392,799; other patents pending in the U.S.A. and worldwide.

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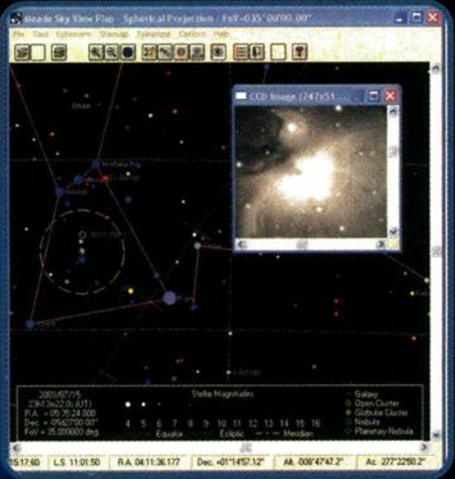

Planetarium program showing Orion region.

The Autostar Suite™ with Meade LPI™ (Lunar Planetary Imager/Autoguider) and Planetarium software turns your Meade telescope, Autostar®, and PC into even more powerful and easy-to-use astronomical instruments!

This exciting new package includes the following features and more* for only **$149:**

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Meade LPI imager mounted on LX200GPS telescope.

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**For use with other Meade telescopes see the Meade web site.

Image of Saturn by Jeff Hobbs taken with an LPI connected to a 12" LX200GPS. The image is a composition of images automatically selected and registered by the Autostar Suite software.

Moon image taken with altazimuth mounted 8" LX90 by first-time user of the LPI imager and software.

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Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. **Ultra Wide Angle** (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™ 2x Apochromatic Barlow Lens

#140: 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images unmatched resolution, contrast and color correction. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (5.26)

2x Short-Focus Barlow (1.25")

#126: 2.5" long, works with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of longer focal-length Barlows. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (4.54)

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Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces). **$42.95** (3.86)

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#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders. **#929** or **#930,** each: **$119.95** (6.85)

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#908B

Series 4000 Nebular Filters—Premium multi-layer interference filters. Broadband ("B") filters block most forms of light pollution; narrowband ("N") filters are for heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

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#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **99.95** (5.26)

#908N–Threads into 1.25" eyepieces, 26mm dia. **89.95** (4.54)

#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia. **119.95** (5.26)

#911X

#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia. **99.95** (4.54)

#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes; 36mm dia. **149.95** (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue — each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
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Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

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Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD

Threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

f/3.3 CCD FOCAL REDUCER

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

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Use with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

#647
#644
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- **Planetarium Software** features over 19 million objects from which you can develop observing lists. The software allows remote control of the telescope from a PC.

$149.00 (8.26)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

T-Adapters for Schmidt-Cassegrains

Rigidly couples 35mm camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

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Machined sliding cell allows variable projection power in eyepiece-projection photography with 35mm cameras; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera. **$39.95** (3.86)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-35mm camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron Schmidt-Cassegrain. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your 35mm camera.

$39.95 (3.86)

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate handbox for use with all other Meade SCT models (e.g., LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.- **$249.95** (9.85)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25". **$149.95** (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator. **$129.95** (5.26)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included. $99.95** (3.45)

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Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

MA12mm Illuminated Reticle Astrometric Eyepiece

A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters, and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25". **$119.95** (4.26)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

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Rigidly couples any 35mm camera with removable lens to ETX-90, ETX-105, or ETX-125 for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics. **$49.95** (3.86)

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#775 for ETX-125 models: **149.95** (13.38)

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The view from above

I teach astronomy to junior high school students on the shore of Lake Malawi in Mozambique. I frequently use photos from *Astronomy* to illustrate topical presentations. The very beautiful 1968 photo of Earth as seen from lunar orbit featured in "The 25 greatest astrophotos in history" (February 2004) will be especially useful on the first day of class. Our students have a very traditional understanding of nature, and this photo will allow them to see Earth, Africa, and the Moon from a totally different perspective. For many students, it will be a challenging concept. — **MARK ALOYS GRUENKE,** ESAM JUNIOR HIGH SCHOOL, METANGULA-LAGO, NIASSA, MOZAMBIQUE

THE MOON SETS OVER EARTH in this image taken from the space shuttle Discovery in 1995. Pictures captured from space provide a unique perspective on our home planet and satellite. NASA

Searching for neutrinos

Alison Boyle and Ken Grimes's otherwise excellent article "Ghostbusting the Universe" (December 2003) fails to mention and give credit to the contributions of the Sudbury Neutrino Observatory (SNO), which is buried deep inside a nickel mine near Sudbury, Ontario, Canada.

In 2001, Dr. McDonald's talented team of researchers, using a 12-meter-diameter sphere filled with heavy water and surrounded by photomultiplier detectors, was the first to prove the oscillation of solar neutrinos because of the higher sensitivity of their apparatus. Since then, with equipment upgrades, the team has been working to "see" and interpret neutrinos from other sources. — **ANTHONY SOSNKOWSKI,** BRACKLEY BEACH, PRINCE EDWARD ISLAND, CANADA

An astronomical limerick

Bob Berman's "Stupidity smarts" (January 2004) reminded me of a limerick I wrote a number of years ago. It was one of many I shared with Isaac Asimov before he passed away, a two-way correspondence that lasted several years and yielded many chuckles.

In 1844, the German astronomer–mathematician Friedrich Wilhelm Bessel, observing a wobble in the path of Sirius, the Dog Star, concluded there must be a companion star too faint to be seen nearby. Alvan Clark, the American telescope builder, later proved him to be right.

Friedrich Wilhelm Bessel
On spotting a wobble mysterious,
This star-gazer near went delirious.
He shouted, "Hey you, star,
You must be a new star,
For surely you cannot be Sirius."

— **LEONARD GREENBERG,** STERLING, VIRGINIA

Greetings from Hawaii

I enjoyed reading the field report by David J. Eicher from the May 2003 trip to Mauna Kea, "From heaven on Earth . . . into thin air" (January 2004). However, the caption on page 80 gives an incorrect order of the telescopes on the east ridge and states the Canada-France-Hawaii Telescope (CFHT) has a silver dome.

CFHT actually is the telescope on the far right with the large white dome. The telescope on the far left that received no mention is the University of Hawaii 0.6-meter telescope. — **DOUG SUMMERS,** W. M. KECK OBSERVATORY, KAMUELA, HAWAII

Corrections

In "The 25 greatest astrophotos in history" by Michael E. Bakich (February 2004), the picture shown on page 35 was taken on December 24, 1968, not December 29.

On page 36, the multiple-Moon daguerreotype at the top of the page was made by Samuel Dwight Humphrey of Canandaigua, New York, on September 1, 1849, not by John A. Whipple, William C. Bond, and George P. Bond.

— ***ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy Letters, P.O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.

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BY BOB BERMAN

Frames of reference

I think I'm sort of smart. And a nice guy, too. But some of my friends insist I'm actually a moron. Who's right? Is there any way to know for sure? Interestingly enough, this is the kind of dilemma physicists confronted one century ago. ☾ Next year is the centennial of some of Einstein's "greatest hits." Thanks to his 1905 special relativity theory, we're all familiar with E=mc^2, which tells us energy and matter are fundamentally the same thing. But most people still overlook his groundbreaking explanation of "reference frames."

Before the 20th century, everyone assumed if you got off at the wrong stop and found yourself on planet Pook in the Hercules cluster, you'd whittle away your time at the same rate as your girlfriend back home in New Jersey. But Einstein realized that distance, mass, time — all sorts of things — have to mutate in various situations, or else physics wouldn't make sense everywhere. This idea, reality changing in different situations or frames, is still widely misunderstood.

Consider muons, those heavy subatomic particles created 35 miles overhead when cosmic rays break apart air atoms. Muons decay naturally and vanish in one millionth of a second, so even zooming along at almost the speed of light shouldn't give them enough time to reach the ground. Yet 240 of those varmints tear through our bodies every second. How do they get here when they're supposed to decay high overhead?

Simple. Their fast speed makes their time slow down. This paradox delays their vanishing act. At least, that's our take on it. But that's not what muons experience. If they could perceive things, they'd feel time passing normally but experience Earth's atmosphere as only a few yards thick, a cinch to penetrate in their brief, trouble-making lives.

The same thing would happen with any future astronauts traveling at, say, 99 percent the speed of light. Leaving Earth, they would feel time pass normally, and they would measure the distance to Sirius as about one light-year. Meanwhile, we on Earth insist the Dog Star is more than 8 light-years in front of them, and we know from monitoring their slurred words and glacial heartbeats that their clocks are seriously screwy. We both disagree about distance and time. We need Einstein to mediate. Whose perspective is correct? He'd say: "You're both right." Distance and time depend on one's frame of reference, which changes with motion or gravity.

This frame business goes way off the weird-meter with black holes. Experts tell us a massive star collapses until it implodes into a singularity, a point, a black hole. That may be true from the perspective of the collapsing star. But for anyone observing it from the outside (meaning the entire rest of the universe, including us), something entirely different happens. We'd see the star collapsing at an ever-slower rate because its rising surface gravity changes its passage of time compared to ours. The outer bits of that star, the last collapsing mass needed to reach black hole status, never reach the critical point. A singularity and event horizon never form. When still more than a mile wide, the star halts and never shrinks one inch more. We see a frozen star, not a black hole.

So, what has really happened? Is our perception some sort of illusion? Do black holes form? Black holes, with their event horizons and singularities, cannot form in our reality. In our universe, they will materialize only after an infinite amount of time has passed, which is a fancy way of saying *never*. So a separate reality, a universe isolated from our own, must exist for the unfortunate star.

Light dwells in a separate frame from us, and it always commutes through spacetime along a route called a null geodesic. Each photon of light would feel itself to be everywhere in the universe at once, with no passage of time. And if astronauts can someday *almost* reach the speed of light, they'd experience things that way, too. They'd be pioneers with the entire cosmos at their beck and call because even the farthest galaxies would be only a mile away. But if they returned, they'd be in for sticker shock. Earth's calendar pages would have flipped ahead, like in those old movies, to *billions* of years in the future. Tattoos and body piercing might be "out." Eating returning astronauts might be "in."

Einstein, you changed everything. Whatever frame of reality you played in, we'll retire its number. ■

{ Billions of years in the future, tattoos and body piercing might be "out." Eating returning astronauts might be "in."

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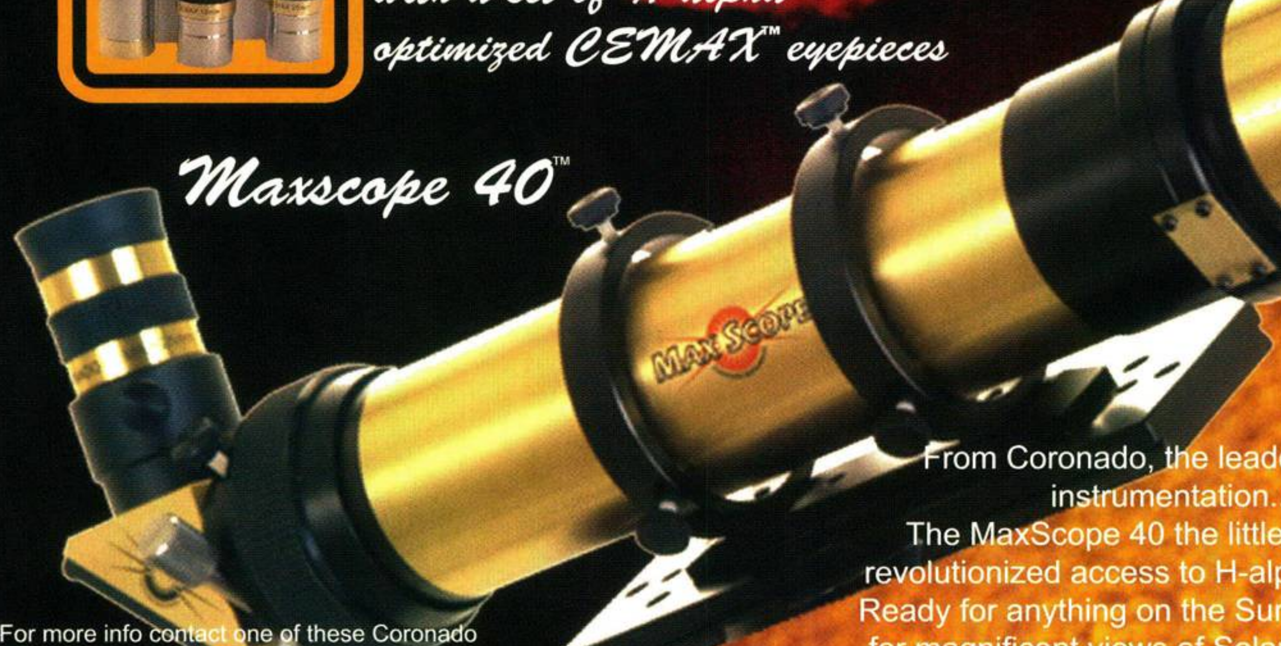

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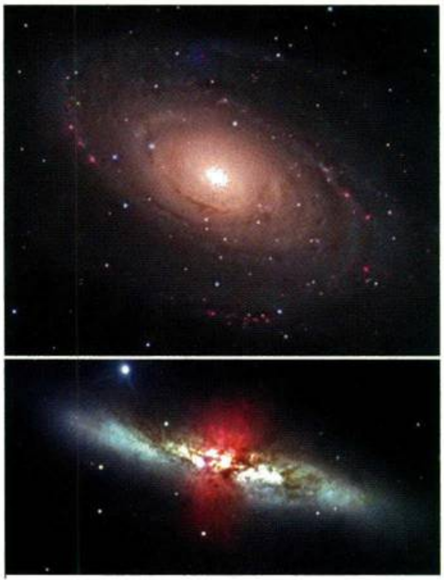
BY GLENN CHAPLE

A tale of two galaxies

During my senior year in high school, my English teacher, Mr. Gardner, emphasized the importance of starting a paper with something scintillating to grab the reader's attention. In keeping with his sound advice, I've crafted a magnificent opener for this month's column — titled "A tale of two galaxies."

It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was . . . What's that? You've read that sentence before? Where? *A Tale of Two Cities* by Charles Dickens? Why that no-good plagiarist! He stole my material! Did Dickens go on to mention two galaxies near the Big Dipper? He didn't? Great! Then I'll continue. . . .

The main characters in "A tale of two galaxies" are M81 and M82. They lie near the bowl of the Big Dipper in Ursa Major, currently positioned high in the northern sky after sunset. Discovered by Johann Bode in December 1774 and cataloged by Charles Messier seven years later, M81 and M82 rank among the brightest galaxies in our night sky. Although visible through standard binoculars under clear dark-sky conditions, this galactic duo requires telescopic scrutiny for a detailed view.



GALAXIES M81 (TOP) AND M82 (bottom) offer observers of all levels an easy-to-find and rewarding sight. M81: CHRIS SCHUR; M82: ROBERT GENDLER

Finding M81 and M82 is as easy as finding the Big Dipper. Center your finder scope on Gamma (γ) Ursa Majoris, then cross the bowl of the Big Dipper diagonally to Alpha (α) Ursa Majoris. Continue an equal distance beyond the star and stop (refer to this month's all-sky map on page 57). With the main scope equipped with a low magnification (30x to 50x), sweep the area slowly. When I "sweep," I peer into the eyepiece, moving my scope slowly from one side of the starting point to the other. If nothing shows up, I repeat the process, moving up and down from the starting point. Sometimes I search in overlapping, outwardly expanding circles. Any way, if I fail to find anything after a minute or two, I check to be sure my finder scope is aligned properly and then try again.

Your search for M81 and M82 will end when you stumble upon two smudges of light — one round and one cigar-shaped. M81 and M82 are less than 1° apart and fit together in the same eyepiece field. After capturing them with low power, switch to a higher magnification for that "up-close-and-personal" view.

M81, a spiral galaxy similar to our Milky Way, is rounder and brighter than M82. Small telescopes reveal an oval blob of light (the galaxy's bright nucleus), whereas larger instruments reveal an outer haze from the spiral arms. Observing guides generally give M81's angular size as 26' by 14', half of which is the nucleus. The Full Moon, by comparison, spans some 30'.

M82 is a galaxy quite different from its neighbor 38' to the south, M81. Even a casual glance shows that M82 is spindle-shaped — 11' long and less than half as wide. Larger telescopes add little dimension but show an intriguing mottled appearance. In photographs, M82 looks downright chaotic, as if a titanic explosion had occurred in its core. Until a few decades ago, astronomers surmised this galaxy was indeed in the throes of a colossal upheaval — possibly a galactic supernova. There is certainly something cataclysmic churning in the bowels of M82, but it's not a galaxy-destroying event.

Last October, I encouraged you to "go deep" and check out the Andromeda Galaxy (M31). M81 and M82 take you even deeper. They are the prominent members of a cluster of a dozen galaxies located about 10 million light-years away.

I was hoping to regale you with another story about a cosmic duo called "A tale of two comets." Again, I'm afraid I've been beaten to the literary punch. This time it wasn't Dickens, but Charles Morris, whose article on comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) begins on page 70. Read his article, then go outside and check out these cosmic visitors — both predicted to reach naked-eye visibility this month. To get two naked-eye comets in the same month is a rare treat.

Oh, and one last thing: Thanks, Richard E. Gardner, for teaching me how to be a writer. I'll begin next month's column with a whale of a sentence. Hey! How about this? "Call me Ishmael." That oughta harpoon the readers.

Next month: How to view the Sun and June's long-anticipated transit of Venus safely, plus, we ask: "Is there such a thing as a green star?" Clear skies.

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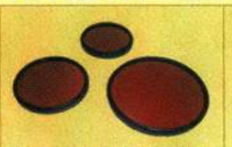
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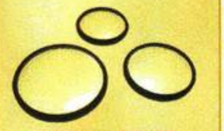
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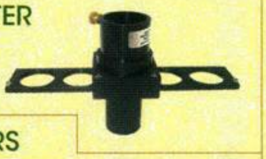

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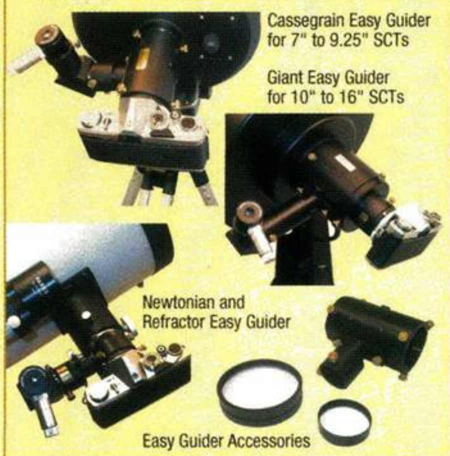
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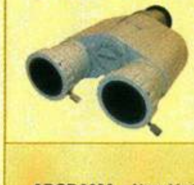

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BY WILLIAM SCHOMAKER

Owen Gingerich

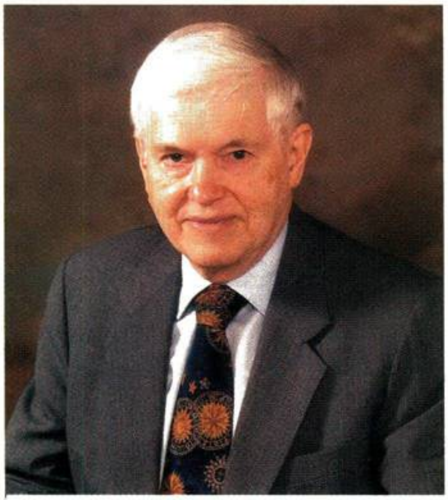
Homeward bound from a transatlantic relief voyage to war-ravaged Poland in 1946, a greenhorn cowboy took advantage of a pit stop in Copenhagen, Denmark, to visit the town's famous observatory — and collided with destiny. Owen Gingerich — now a research professor of astronomy and the history of science at the Harvard-Smithsonian Center for Astrophysics — is a self-confessed man of deep faith, and one of the foremost scholars on the intersection of science with faith and history. In his new, ironically titled tome about the book that birthed the notion of a Sun-centered solar system, Gingerich comes clean on everything from his book-hunting adventures behind the Iron Curtain to his artistic collaboration wtih documentary filmmaker Charles Eames.

What has fueled your 30-year obsession with Copernicus's *On the Revolutions*?

With the 400th anniversary of Kepler's birth in 1971, and the Copernican Quinquecentennial in 1973, I became fascinated by the historical insights one could get about science. You can learn about science by *doing* science. But, in many ways, you get a better perspective if you're looking at its *historical development* — about what its claims to truth are and how theories interact with observations.

Why did the Copernican revolution burn such a deep mark on the human psyche?

The Copernican revolution was bound tightly to a sacred geography of an unmoving Earth that had come into Christendom in the West. It was a picture of hell within the bowels of Earth and heaven not that far beyond the stars. The dismantling and reconstruction of our view of the cosmos was pretty traumatic to people wed to that kind of view.



OWEN GINGERICH recently authored *The Book Nobody Read: Chasing the Revolutions of Nicolaus Copernicus*. BACHRACH

Other paradigm shifts aren't necessarily bound to the human psyche. The 20th century's quantum mechanical revolution was profound in how it shook physics, but it doesn't come down to the everyday views about what the universe is like. So it doesn't meet the same kind of resistance.

Why is there such a schism between science and spirituality today? After all, Kepler and Copernicus were holy men.

We're talking about a much larger universe in which many things that would have been seen in the 16th century as miraculous now have physical explanations. So the idea of a nearby, personal God who pays attention to what we do is much harder to believe. So it's a different ethos about how things are explained that contributes to making it harder today to merge faith with science. Still, many important scientists are also folks of deep faith.

Is there room for beauty and creativity within the pursuit of science?

A lot of people currently work on a kind of normal, inventive science. But you would not necessarily say they're being creative. Sometimes, however, you find people — Copernicus, Newton, Einstein — with insights that help produce a greater level of unification. And that, I think, is a powerful, creative act — just as creative as Beethoven composing the ninth symphony or Shakespeare writing *King Lear*.

Searching for the beauty behind scientific theory is a very powerful, yet seductive, ideal. To Copernicus and his contemporaries, uniform celestial motion was imperative for any explanation of the heavens. That's a beautiful aesthetic idea, but it turns out to be just dead wrong.

Did your research really shatter a young party member's belief in communism?

The young man was a convinced Marxist functionary who was serving as the gatekeeper for the university library [in Halle, East Germany]. And he was dead-set on getting me straight about what the younger generation believed there. When I revealed I knew where the library's long-presumed stolen copy of [*On the Revolutions*] was — that it had been inscribed by the rector of the university as a gift to the "liberating" Russian general — he was deeply shocked. As he realized I wasn't just making the story up — that the book was actually *in* the Lenin library in Moscow where I had seen it — his attitude changed suddenly, as if his entire worldview was crumbling beneath him.

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DS-2070 AT 2.8" f/10 GO-TO Refractor	$264.95
DS-2114 ATS 4.5" f/8.8 GO-TO Reflector	$374.95

SPOTTING SCOPES

ETX 90	CALL
ETX 90 w/UHTC	CALL
ETX 125	CALL
ETX 125 w/UHTC	CALL

LX 200 GPS

SCHMIDT-CASSEGRAINS

The Meade LX200GPS, the most important advanced Schmidt-Cassegrain technology in 10-years, is here!

Standard equipment includes:

- 16-channel GPS receiver
- GO TO pointing position
- High-Precision Pointing mode
- Zero image-shift micro-focuser
- 40-hour internal battery
- Magnetic declination compensation
- Auto-Star II hand controller accesses 125,000 object database

LX-200 GPS 7" Maksutov-Cassegrain	$2,495
LX-200 GPS 7" Maksutov-Cassegrain, w/UHTC	$2,645
LX-200 GPS 8"	CALL FOR LOW PRICE
LX-200 GPS 8" w/UHTC	CALL FOR LOW PRICE
LX-200 GPS 10"	CALL FOR LOW PRICE
LX-200 GPS 10" w/UHTC	CALL FOR LOW PRICE
LX-200 GPS 12"	CALL FOR LOW PRICE
LX-200 GPS 12" w/UHTC	CALL FOR LOW PRICE
LX-200 GPS 14"	$4,295
LX-200 GPS 14" w/UHTC	$4,695
LX-200 GPS 16"	CALL

SMART MOUNT ALSO AVAILABLE

LX SCOPES

8" LX-90 Schmidt-Cassegrain	$1,695
8" LX-90 Schmidt-Cassegrain w/UHTC	$1,870
8" LX-10 Schmidt-Cassegrain	CALL
8" LX-10 Schmidt-Cassegrain w/UHTC	CALL
8" LX-10 Schmidt-Cassegrain Deluxe	CALL
8" LX-10 Schmidt-Cassegrain Deluxe w/UHTC	CALL

ED REFRACTORS

4" 102 ED Apochromatic	$2,777.50
5" 127 ED Apochromatic	$3,277.95
6" 152 ED Apochromatic	$4,859.95
7" 178 ED Apochromatic	$5,896.95

STARFINDERS

16" Equatorial	CALL
16" Dobsonian	CALL
12.5" Dobsonian	CALL

BINOCULARS

TRAVELVIEW SERIES

9 x 63 Roof Prism	CALL
8 x 42 Roof Prism WP w/compass	$114.95
10 x 42 Roof Prism WP w/compass	$119.95
7 x 42 Roof Prism WP multi-coated prisms	$224.95
10 x 42 Roof Prism WP multi-coated prisms	$269.95

CAPTUREVIEW SERIES

8 x 22 VGA	$79.95
8 x 30 1.3 mp	$114.95
8 x 42 2.0 mp, color LCD	$185.95

EYEPIECES

SERIES 4000 SUPER PLOSSLS

6.4mm	$79.95	9.7mm	$79.95
12.4mm	$79.95	15mm	$79.95
20mm	$79.95	26mm	$79.95
32mm	$99.95	40mm	$99.95
56mm	$199.95		

SERIES 4000 SUPER WIDE ANGLE

13.8mm	$139.95	18mm	$149.95
24.5mm	$179.95	32mm	$239.95
40mm	$299.95		

SERIES 4000 ULTRA WIDE ANGLE

4.7mm	$169.95	6.7mm	$199.95
8.8mm	$239.95	14mm	$299.95

SERIES 4000 ZOOM EYEPIECE

8-24mm zoom	$219.95

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#126 2x short focus (1.25")	$44.95
#127 2x-3x variable (1.25")	$56.95
#134 Achromatic (.96")	$44.95
#140 2x Apochromatic (1.25")	$77.95

ILLUMINATED RETICLE EYEPIECES

9mm w/cord	$129.95	9mm wireless	$149.95
12mm w/cord	$79.95	12mm wireless	$99.95
12mm Astromatic	$119.95		
25mm Plossl CCD framing ocular	$129.95		
Electronic Eyepiece	CALL		

FILTERS

SERIES 4000 PHOTO VISUAL FILTERS

#8 Light Yellow	$14.95	#11 Yellow-Green	$14.95
#12 Yellow	$14.95	#21 Orange	$14.95
#23A Light Red	$14.95	#25A Red	$14.95
#38A Dark Blue	$14.95	#47 Violet	$14.95
#56 Light Green	$14.95	#58 Green	$14.95
#80A Blue	$14.95	#82A Light Blue	$14.95
Moon Filter #ND96	$16.95		
Filter Set #1 includes #s: 12/23A/58/80A	$49.95		
Filter Set #2 includes #s: 11/25A/47/82A	$49.95		
Filter Set #3 includes #s: 8/21/38A/56	$49.95		

SERIES 4000 NEBULAR FILTERS

#908B	$79.95	#908N	$89.95
#911B	$99.95	#911N	$119.95

SERIES 4000 OXYGEN FILTERS

#908X	$99.95	#911X	$149.95

ACCESSORIES

#62 T-Adapter f/Schmidt Cassegrain	$26.95
Camera Adapter 1.25"	$29.95
Camera Adapter .96"	$27.95
Variable-Projection CameraAdapter 1.25"	$39.95
Variable Tele-Extender	$39.95
#905 Variable Polarizer 1.25"	$49.95
#1209 Zero Image-Shift Microfocuser	$249.95
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F/6.3 Focal Reducer	$129.95
#927 45° Erect Image Diagonal Prism - .96"	$42.95
#928 45° Erect Image Diagonal Prism - 1.25"	$42.95
#607 25" Cigarette Adapter	$25.00
Off Axis Guider	$79.95

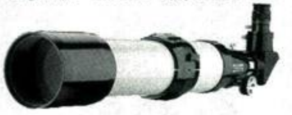
CCD-PHOTO-VISUAL FLIP-MIRROR SYSTEM

#644	$149.95
#647	$249.95
#157 1.25" adapter	$15.00

SCOPES

102 Package

Tube: 4" Ivory • f/: 8.6 • Focuser: 2" • Case: Hard
Diagonal: 2" • Everbrite • Eyepiece: 20 Plossl



NP 101

Tube Color: Ivory• f/: 5.4• Focuser: 2"
Diagonal: 2" Everbrite • Case: Hard

102 Package	$2,635
102i Package	$3,580
NP 101	$3,595
TeleVue 85 Package	$2,080
TeleVue 76 Package	$1,675
Pronto Package	$2,080
Ranger Package	$760

EYEPIECES

PLOSSLS

55mm	$228	20mm	$95
40mm	$110	15mm	$82
32mm	$110	11mm	$82
25mm	$95	8mm	$82

RADIAN

18mm	$240	8mm	$240
14mm	$240	6mm	$240
12mm	$240	5mm	$240
10mm	$240	4mm	$240
3mm	$240		

NAGLER

31mm Type 5	$620	12mm Type 4	$355
26mm Type 5	$580	9mm Type 6	$280
22mm Type 4	$460	7mm Type 6	$280
17mm Type 4	$385	7mm	$190
16mm Type 5	$320	5mm Type 6	$280
13mm Type 6	$280	4.8mm	$155

ZOOM

3-6mm	$380	8-24mm	$210

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2x Powermate	$280	5x Powermate	$168
2.5x Powermate	$168	2x Barlow	$105
4x Powermate	$295	2x Big Barlow	$198
3x Barlow	$105		

ACCESSORIES

Ash Panoramic Mount	$495
Ash Gibraltar Mount	$595
Ash Panoramic w/SkyTour installed	$1205
Ash Gibraltar w/SkyTour installed	$1365
BinoView	$1030
Eyepiece Carrying Bag	$125
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CELESTRON

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NexStar 8 GPS

Images in the NexStar 8 are over two times brighter than with a 5" telescope. With the touch of a button, the NexStar 8 GPS will open the door to planets,galaxies and nebulae that you have never experienced in your lifetime.

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NexStar 8 GPS XLT	$2,124
NexStar 9-1/4 GPS	$2,699
NexStar 9-1/4 GPS XLT	$2,874
NexStar 11 GPS	$2,999
NexStar 11 GPS XLT	$3,224
NexStar 5i Kit	$950
NexStar 8i Kit	$1,199
NexStar 8i Kit XLT	CALL
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NexStar 80 GT	$299.95
NexStar 114 GT (#31142)	$299.95
NexStar 130 GT	CALL
NexStar 4 GT	$449.95

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The FirstScope Series is designed with the first-time telescope buyer in mind. These scopes feature compact and portable designs with ample optical performance to excite any newcomer.

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Firstscope 60 EQ	$104.95
Firstscope 70 EQ	$144.95
Firstscope 76 Table Top	$89.95
Firstscope 76 EQ	$139.95
Firstscope 80 AZ	$219.95
Firstscope 80 EQ	$229.95
Firstscope 102 AZ 102mm (4"), 1000mm f/10	$329.95
Firstscope 114 EQ 114mm (4.5")	$219.95
Firstscope 114 Short	$154.95

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Power Seeker 60 EQ	$79.95
Power Seeker 114 EQ	$119.95

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GPS Module CN16	$175
AC Adapter or Car Battery Adapter	$19
Focal Reducer	$110
Hand Controller (f/NexStar 5i & 8i)	$149
Flashlight Night Vision	$20
Power Tank	$65

FILTERS

Contrast-Booster Filter	$45
Eyepiece Filter Set (94119-10) w/21, 80A, 15, polarizer	$49
Eyepiece Filter Set (94119-20) w/12, 25, 56, ND-25	$49
Eyepiece Filter Set (94119-30) w/23A, 38A, 58, ND-50	$49
Eyepiece Filter Set (94119-40) w/8, ND-13, 47, 82A	$49
Polarizing Filter Set (93608) 1.25"	$49
Skylight Filter f/ Schmidt-Cassegrains	$45
Moon Filter 1.25"	$19

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REGAL LS SERIES

10 x 50	$399.95
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C5-S 5" Schmidt-Cassegrain, 1250mm f/10	$849
C6-N 6" Reflector, 750mm f/5	$399
C6-R 6" Refractor, 1200mm f/8	$799
C8-S 8" Schmidt-Cassegrain, 2032mm f/10	$999
C8-S XLT 8" Schmidt-Cassegrain, 2032mm f/10	$1124
C8-N 8" Reflector, 1000mm f/5	$649
C9¼S 9.25" Schmidt-Cassegrain, 2350mm f/10	$1399
C9¼S XLT 9.25" Schmidt-Cassegrain, 2350mm f/10	$1574
C10-N 10" Reflector, 1200mm f/4.7	$849

COMPUTERIZED

C5-S GT 5" Schmidt-Cassegrain, 1250mm f/10	$1099
C6-R GT 6" Refractor, 1200mm f/8	$999
C8-N GT 8" Reflector, 1000mm f/5	$949
C8-S GT 8" Schmidt-Cassegrain, 2032mm f/10	$1299
C8-S GT XLT 8" Schmidt-Cassegrain, 2032mm f/10	$1424
C9¼S GT 9.25" Schmidt-Cassegrain, 2350mm f/10	$1699
C9¼S GT XLT 9.25" Schmidt-Cassegrain, 2350mm f/10	$1874
C10-N GT 10" Reflector, 1200mm f/4.7	$1149

CGE SERIES

CGE Computerized Mount	$2,999
CGE 800 8" Schmidt-Cassegrain, 2032mm f/10	$3,499
CGE 800 XLT 8" Schmidt-Cassegrain, 2032mm f/10	$3,625
CGE 925 9.25" Schmidt-Cassegrain, 2350mm f/10	$3,799
CGE 925 XLT 9.25" Schmidt-Cassegrain, 2350mm f/10	$3,975
CGE 1400 14" Schmidt-Cassegrain, 2910mm f/10	$5,799
CGE 1400 XLT 14" Schmidt-Cassegrain, 2910mm f/10	$6,075

SPOTTING SCOPES

C5 Spotter

- Fully multicoated optics
- Excellent light gathering ability
- Standard 8x20 erect image finderscope
- Near focus of 20'
- 45° erect image diag. & 25mm Plossl
- 22mm eye relief and 1° field of view with standard eyepiece

C5 5" Schmidt-Cassegrain, 1250mm f/10	$549.95
C90 Multi-coated	CALL
102 Wide View 4", 102mm Refractor 500mm f/5	$199.95
80 Wide View 3.1" Refractor, 400mm f/5	$149.95
60 Pro Zoom 60mm Refractor	$199.95

EYEPIECES

E-Lux 6mm, 1.25"	$29.95	**E-Lux** 10mm, 1.25"	$29.95
E-Lux 25mm, 1.25"	$29.95	**E-Lux** 40mm, 1.25"	$34.95
E-Lux 26mm, 2"	$54.95	**E-Lux** 32mm, 2"	$59.95
E-Lux 40mm, 2"	$64.95		
Omni 4mm, 1.25"	$45	**Omni** 6mm, 1.25"	$45
Omni 9mm, 1.25"	$45	**Omni** 12.5mm, 1.25"	$45
Omni 15mm, 1.25"	$45	**Omni** 20mm, 1.25"	$45
Omni 25mm, 1.25"	$45	**Omni** 32mm, 1.25"	$49.95
Omni 40mm, 1.25"	$49.95	**Omni** 2x Barlow	$45
X-Cel 2.3mm, 1.25"	$64	**X-Cel** 5mm, 1.25"	$64
X-Cel 8mm, 1.25"	$64	**X-Cel** 10mm, 1.25"	$64
X-Cel 12.5mm, 1.25"	$64	**X-Cel** 18mm, 1.25"	$64
X-Cel 21mm, 1.25"	$64	**X-Cel** 25mm, 1.25"	$64
Ultima 5/7.5mm, 1.25"	$75	**Ultima** 10mm, 1.25"	$75
Ultima 12.5mm, 1.25"	$75	**Ultima** 18mm, 1.25"	$75
Ultima 30mm, 1.25"	$90	**Ultima** 35mm, 1.25"	$105
Ultima 42mm, 1.25"	$90	**Ultima** 2x Barlow	$75
Axiom 15mm, 1.25"	$129	**Axiom** 19mm, 1.25"	$139
Axiom 23mm, 1.25"	$149	**Axiom** 19mm, 2"	$175
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Leica

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8 x 42 BN Black	$1045
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EYEPIECES

Ocular B 40 x 32	$269
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Ocular B 20-60x X 16-48	CALL

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Case for Televid Straight/Angle	$199
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16-47 x 60 Spotter XL Outfit	$426
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BINOCULARS

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7 x 50 FMT-SX	$541

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Super 80 ED	$988

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BINOCULARS

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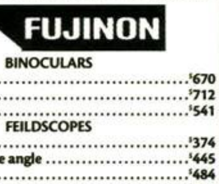
10 x 56 B T P	$1,349.99
12 x 56 B T P	$1,499.99
20 x 60 BS/GA T Stabilized	$4,999.99

Kowa

SPOTTINGSCOPES

TSN-821m	$599	TSN-822m	$559
TSN-823m	$1324	TSN-824m	$1199
TSN-661m	$475	TSN-662m	$425
TSN-663m	$750	TSN-664m	$725
TSN-601m	$325	TSN-602m	$305

SWIFT



Dobsonian Telescope #859D	$359
Reflecting Telescope #863R	$215
Refracting Telescope #862R	$136
Newtonian Telescope #864	$310
Achromatic Telescope #865	$435
Brass Terrestrial #868A	$1649

BINOCULARS

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20 x 80 Satellite	$359
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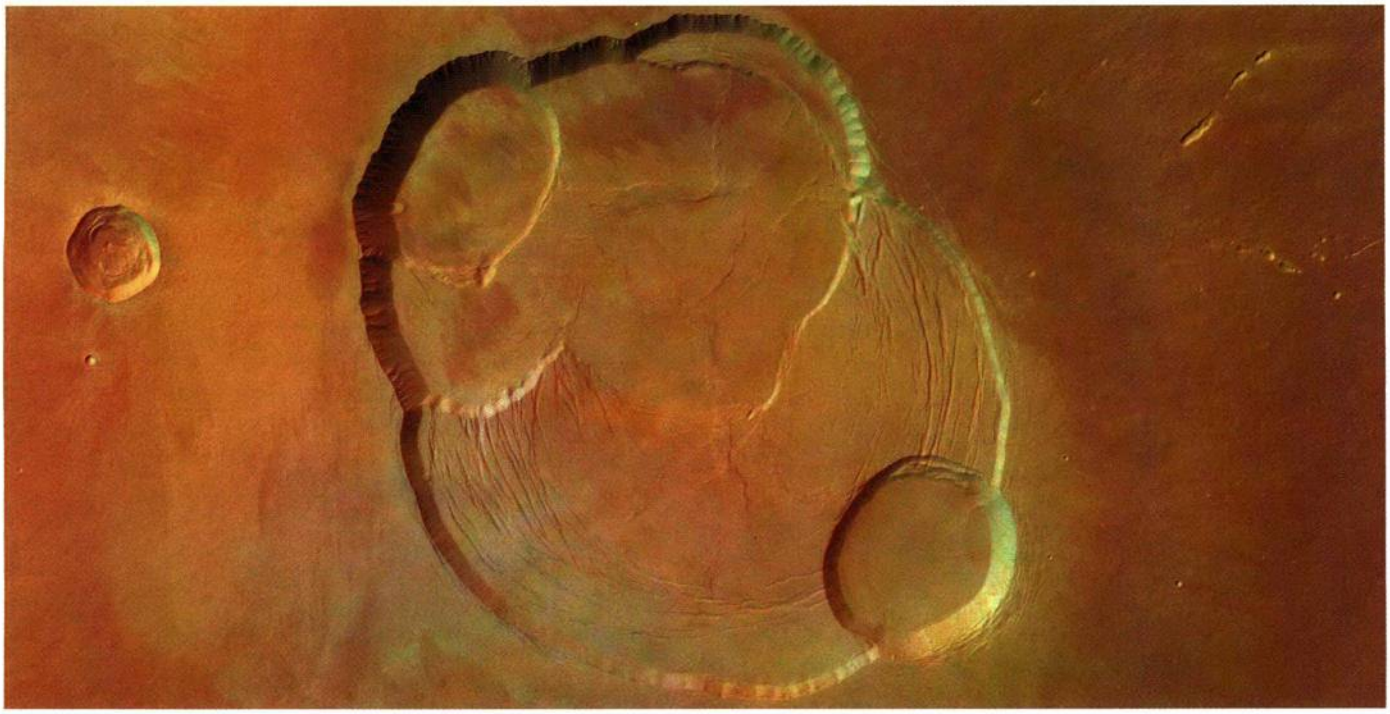
THE PLEIADES LIE 440 LIGHT-YEARS AWAY, a newly determined distance that contradicts results of the Hipparcos astrometry satellite. If Hipparcos is systematically in error, 100,000 more stars' distances are also wrong.

news 05

Read all about it: the farthest and oldest galaxy ever seen, color-coded differences between Uranus and Neptune, and stars growing in a nursery.

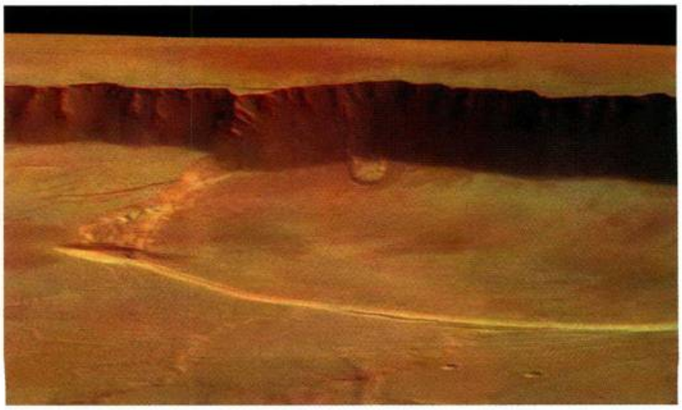


28 Sending a MESSENGER from Earth to Mercury

30 Galactic merger gives a black eye

32 Supernova starburst in a dwarf galaxy

Mars Express: Olympus Mons at high resolution



GIGANTIC COLLAPSES enlarged the volcanic caldera atop Olympus Mons on Mars, above. (North lies to the right.) The caldera spans 50 miles (80 km) and is 2 miles (3 km) deep. As magma withdrew following eruptions, parts of the summit collapsed, leaving circular scars. At left, an oblique view, created from stereo images (and vertically exaggerated 1.8 times), looks south. It shows the caldera's buckled floor, the steep scarp of its inner wall, and a landslide. ESA/DLR/FU BERLIN (G. NEUKUM)

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Meade ETX Series of Telescopes

The ETX Series telescopes and mounts are proven leaders in GOTO capability. Introduced in the late '90s, they revolutionized the telescope industry with their compactness – which made them ultra-portable – their optical resolution and their overall performance.

The ETX family of telescopes features a long list of standard equipment, including rigid fork mounts, dual-axis drive systems, cordless field operations and an internal flip-mirror system. These reasonably priced, well-built telescopes offer a full range of viewing experiences for the beginner to the advanced astronomer.

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Meade ETX 105 AT with UHTC Coatings	$870
Meade ETX 125 AT	$995
Meade ETX 125 AT with UHTC Coatings	$1090

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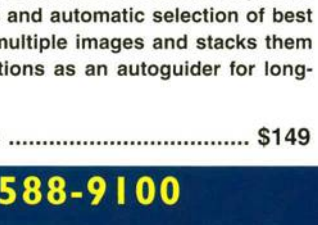

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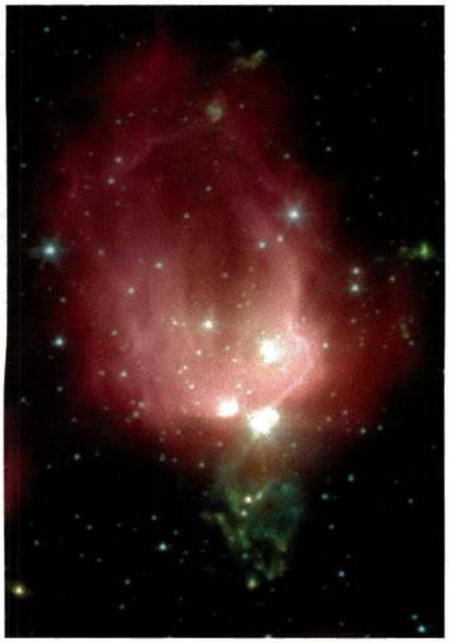
STELLAR ASTRONOMY

Rosebud nursery for growing stars

The Spitzer Space Telescope (formerly SIRTF) has taken the most penetrating image yet made of reflection nebula NGC 7129. This cloud of gas and dust contains about 130 young stars and lies some 3,300 light-years away in the constellation Cepheus. It spreads about 10 light-years across and is faintly visible in large backyard telescopes.

Astronomer Tom Megeath (Harvard-Smithsonian Center for Astrophysics) led the team that made the observations. "We're hoping to understand how stars form in the crowded conditions of a stellar nursery," he says. Stars are typically born inside dense clouds of gas and dust, which are blown away as the stars mature.

The image combines exposures in four infrared colors. The rosy hue indicates warm dust and exposed new stars, while green shows regions where newborn stars are still hidden. — **ROBERT BURNHAM**



LIGHT FROM NEWBORN STARS illuminates the dusty gas in the rosebud-shaped nebula NGC 7129. The Sun was born inside a molecular cloud such as this. NASA/JPL-CALTECH/T. MEGEATH, CFA

Sending a MESSENGER to Mercury

The planet Mercury isn't just hard to see, it's hard to reach. And it's even harder to place a spacecraft into orbit around this namesake of the fleet-footed messenger of the Olympian gods.

So when NASA's MESSENGER probe — for MErcury Surface, Space ENvironment, GEochemistry, and Ranging — is launched this month, it will take a roundabout space route in order to approach the planet slowly enough that its rockets can steer it into a safe survey orbit. Five planetary flybys — three of Venus and two of Mercury itself — will shape the orbit into the gentlest-possible final approach. It will take a five-year flight to do this.

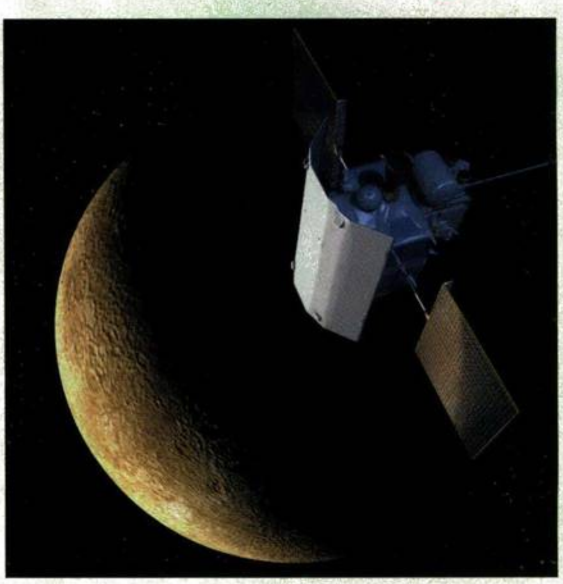
Thirty years ago, NASA's Mariner 10 pioneered the Earth-Venus-Mercury route and made three flybys of Mercury. Mariner imaged about half the surface of Mercury and measured its magnetic field and unusual density. MESSENGER will build upon that basis and also pursue mysteries undetected by Mariner 10, particularly the planet's strange polar deposits that may be water ice.

Beginning at the first Mercury flyby in October 2007, and intensively after reaching orbit in July 2009, the probe will remotely measure the geochemistry of surface rocks to test different theories of the planet's origin. The spacecraft will measure the magnetic field and perhaps provide clues that, by comparison, will help us understand Earth's own magnetic field. And from its polar orbit, it will "sniff" the perpetually-shadowed polar craters to see if hydrogen is leaking away or not. (Hydrogen would suggest water ice; a lack of it supports a theory that the radar-reflecting deposits are sulfur.) The baseline science mission will last about one Earth year, which is four mercurian years.

MESSENGER's results will help scientists plan a proposed European Space Agency mission, named BepiColombo, to orbit Mercury a decade from now. By then, MESSENGER will have completed its entire mission.

MESSENGER will be protected from solar heating more than 10 times that at Earth by a ceramic cloth sunshade. Flight controllers will also have strict rules never to turn the craft's solar panels face-on to the Sun.

Although most interplanetary missions have been flown from NASA's Jet Propulsion Laboratory in California, MESSENGER is controlled from Johns Hopkins University's Applied Physics Lab in Maryland, the team that conducted the spectacularly successful NEAR mission to the asteroid Eros. — **JAMES OBERG**



MOON-LIKE BUT NOT ENTIRELY describes Mercury, the target for MESSENGER, due to launch in May. Only one spacecraft has visited Mercury, and that was in 1974–5. NASA/JHUAPL/CIW ARTWORK

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IT'S NOT A RACE, BUT... The Sloan Digital Sky Survey found 13 quasars at redshifts of 6.5 to 7, just less than the galaxy, below left. This implies supermassive black holes, which power quasars, formed soon after the Big Bang.

COSMOLOGY

HST, Keck find a galaxy from the "Dark Ages"

The oldest and most far-off galaxy yet detected — 13 billion light-years away — has been found by astronomers using the Hubble Space Telescope and Keck Telescope.

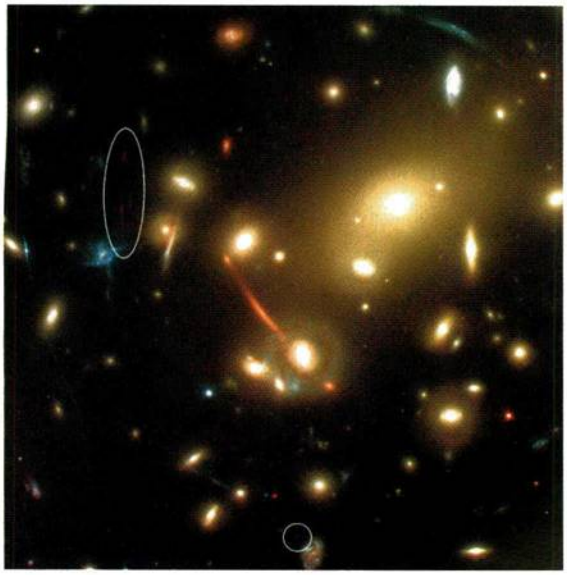
The galaxy appears as it was only 750 million years post-Big Bang. This is just after the period astronomers term "the Dark Ages," before the universe became transparent to light. The discovery should help astronomers explore this early era.

The galaxy's image is greatly distorted by the gravity of an intervening galaxy cluster called Abell 2218. Jean-Paul Kneib (Observatoire Midi-Pyrénées) led the team making the discovery. He says, "We detected a pair of images whose arrangement and similar color indicated they were very distant."

Without the lensing effect of Abell 2218, he adds, the galaxy would shine 25 times dimmer — too faint to be studied by present instruments.

Keck observations found the galaxy has a redshift of around 7, the highest known. Redshift reflects the universe's expansion and measures cosmological distances.

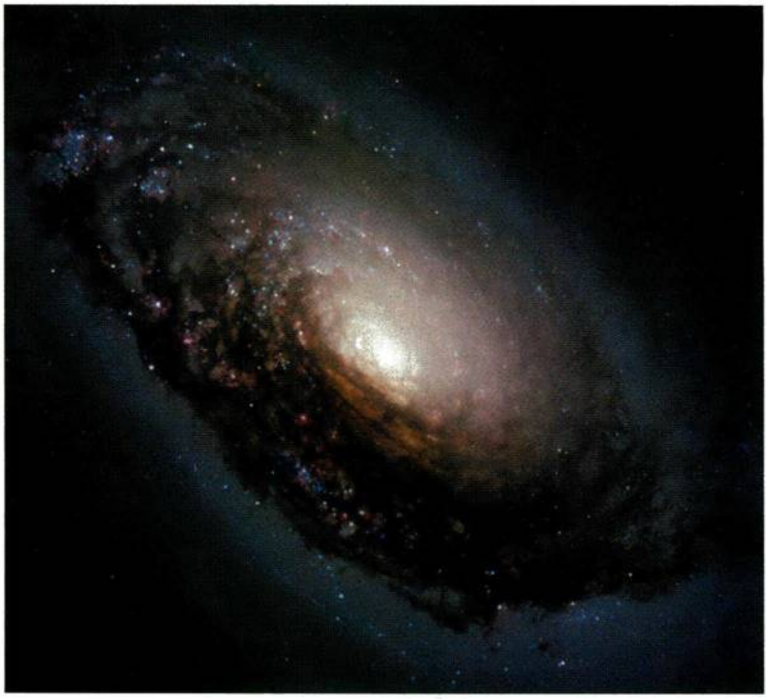
The galaxy appears to be making stars at a rate of about three suns per year, while it spans 3,900 light-years, 1/25 the Milky Way's size. — **R. B.**



A STREAK AND A SMUDGE [circled] mark the distorted image of the oldest galaxy detected. Strongly lensed by the gravity of the foreground galaxy cluster Abell 2218, the distant galaxy dates from just 750 million years after the Big Bang. ESA/NASA

HUBBLE HERITAGE IMAGE

Galactic merger gives a black eye



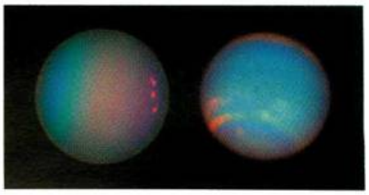
TWO GALAXIES COLLIDED perhaps a billion years ago, and the survivor wears a black eye made of dust. M64, as imaged by the Hubble Space Telescope, rotates clockwise, but gas in its outer regions rotates in the opposite direction. Astronomers attribute the disparity to M64 absorbing a smaller satellite galaxy ages ago. NASA/STScI/HUBBLE HERITAGE TEAM

PLANETARY SCIENCE

Uranus, Neptune looking less alike

Uranus and Neptune look almost like twins to the eye. But Hubble Space Telescope observations with enhanced color filters reveal features in their atmospheres that show them as distinctly different.

Erich Karkoschka (University of Arizona) chose filters that clearly highlight the differences between the gas-giant planets.



URANUS AND NEPTUNE [right] reveal features in their atmospheres when seen in enhanced color. NASA/E. KARKOSCHKA, U. ARIZONA

Atmospheric bands of clouds and haze appear neatly aligned parallel to the equator of each, but Uranus shows more contrast between its hemispheres. Clouds of methane appear orange or red, and a color-coded layering effect will let scientists determine the altitude and thickness of various features.

"The enhanced-color images show how an instrument with different spectral sensitivity than that of the human eye can change the view," says Karkoschka. "There is *more to everything* than what the eye can see." — **ANDREW FAZEKAS**

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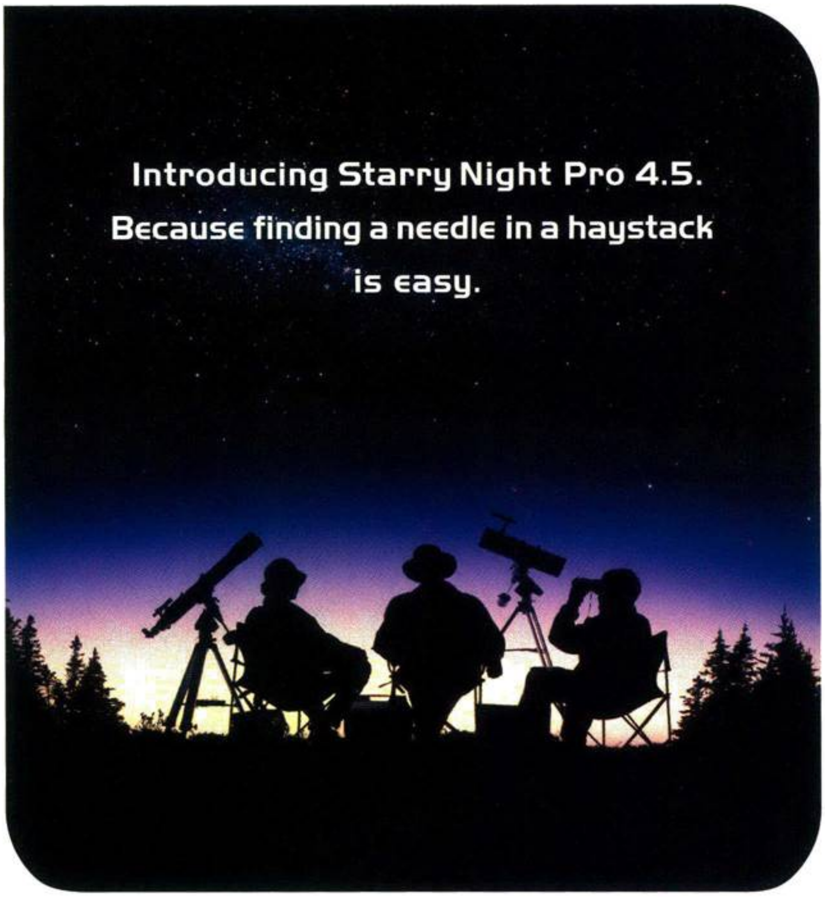

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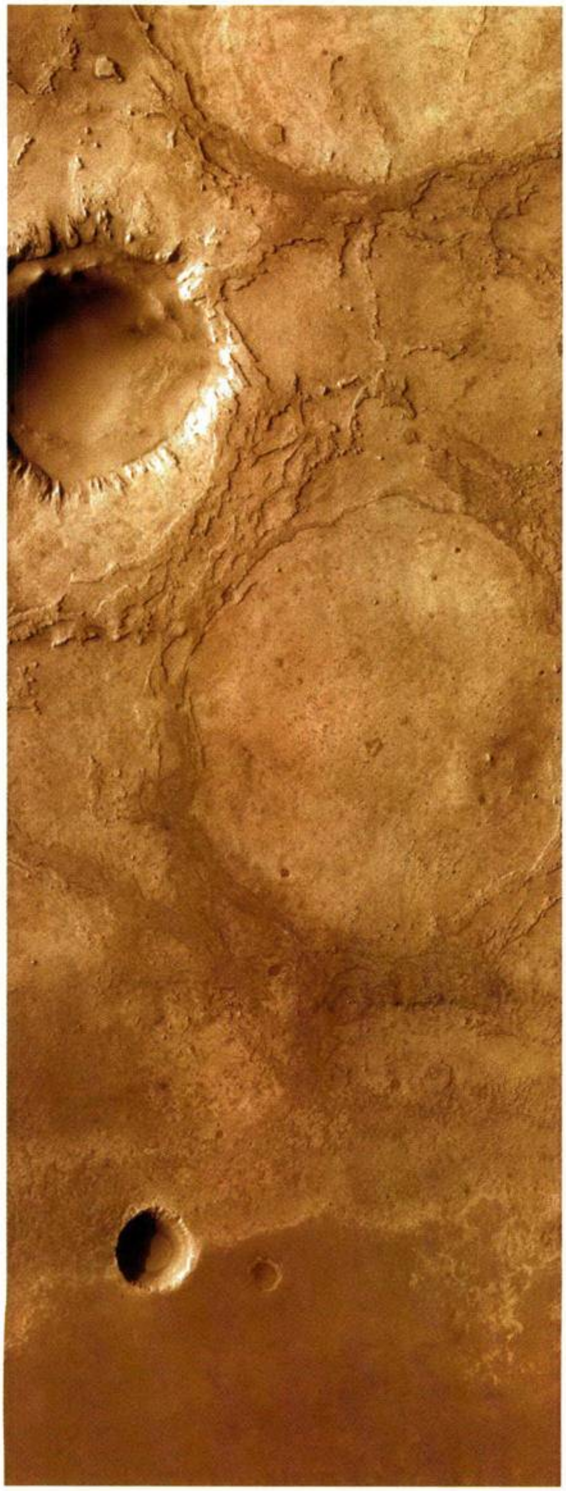
THE LARGEST KUIPER BELT OBJECT after Pluto has been found 39.5 AU from the Sun. With a 248-year orbit, 2004 DW appears to be about 1,000 miles (1,600 km) in diameter, making it slightly bigger than Pluto's moon Charon.

Meridiani: old and older



MERIDIANI PLANUM shows both smooth terrain and much older and rougher ground with battered, eroded craters. Mars rover Opportunity landed not far south of here. NASA/JPL/ASU/IMAGE 20040127A

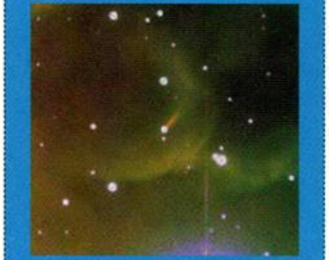
STELLAR ASTROPHYSICS

Young star ejects jet

Astronomers have found a new Rosette Nebula star jetting knots of material at speeds of 1,500 miles (2,500 km) per second.

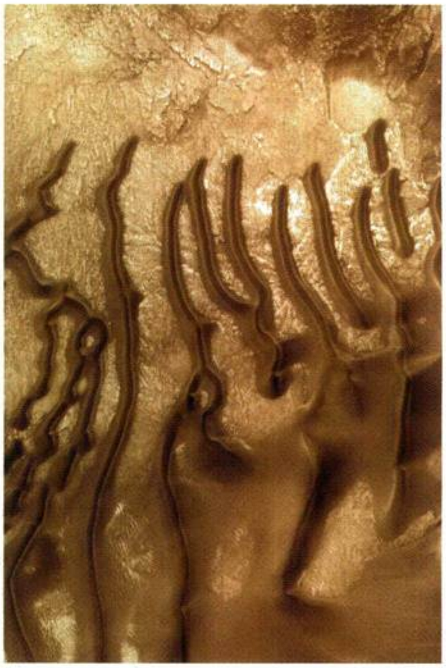
Jin Zeng Li (Chinese Academy of Sciences) and Travis Rector (Univ. of Alaska) measured the jet as 8,000 AU long. Shocks seen on the far side of the star suggest a counter-jet that has become weakened.

Says Jin, "This infant star may have been starved of material as its accretion disk evaporated, leaving a very low-mass star. This process may result in a brown dwarf or a planetary-mass object." — A. F.



A JET SHOOTS from a young star deep in the Rosette Nebula. T. RECTOR, UNIV. ALASKA/WIYN/NOAO

MARS PHOTOJOURNAL



DARK DUNES CRAWL across the floor of a large crater in eastern Noachis Terra, near 49° south and 326° west. Martian dunes are often dark, a token of their origin in iron- and magnesium-rich volcanic rocks. The image, sunlit from the upper left, covers an area about 1.9 miles (3 kilometers) wide. NASA/JPL/MALIN SPACE SCIENCE SYSTEMS/IMAGE E12-01876

STELLAR ASTROPHYSICS

Supernova starburst in dwarf galaxy

About 25 million years ago, dwarf galaxy NGC 1569 began a burst of star formation that lasted for about 20 million years. During the episode, supernova explosions carved hollows in the galaxy as brilliant clusters of hot blue stars emerged from clouds of dusty gas.

SHOCKED HYDROGEN gas glows red under a barrage of radiation from hot stars in dwarf galaxy NGC 1569. ESA/NASA

Peter Anders (Göttingen University) led a team studying the galaxy with the Hubble Space Telescope. Anders says, "These clusters present us with a fossil record of the galaxy's intense star-formation history."

The first and most massive stars to form have already blown up as supernovae, disturbing the interstellar environment. The explosion debris, plus the shock waves, contributes to the formation of new stars. The team reported their results in the *Monthly Notices of the Royal Astronomical Society* for January 1, 2004. — **R. B.**

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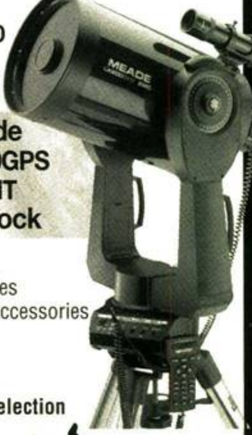

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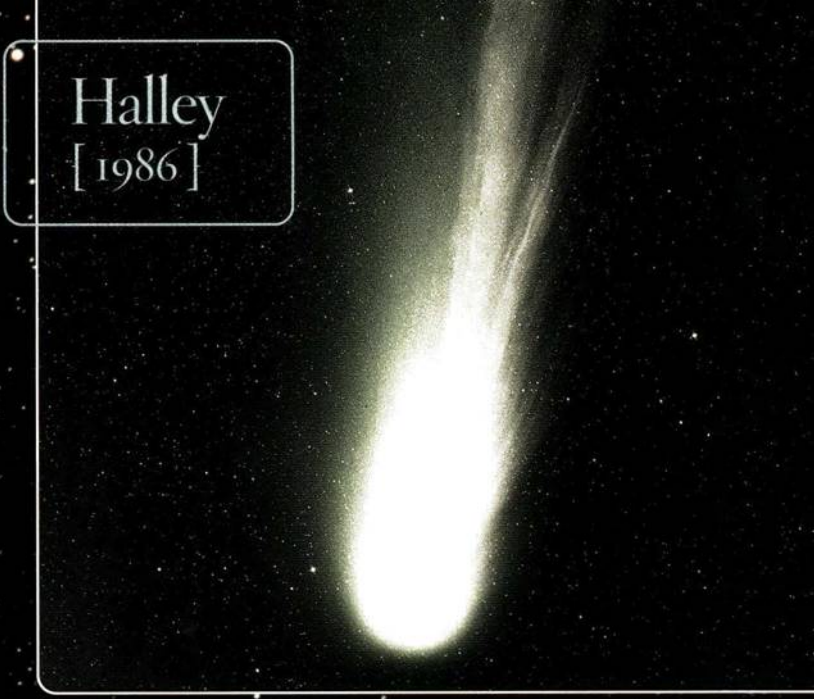
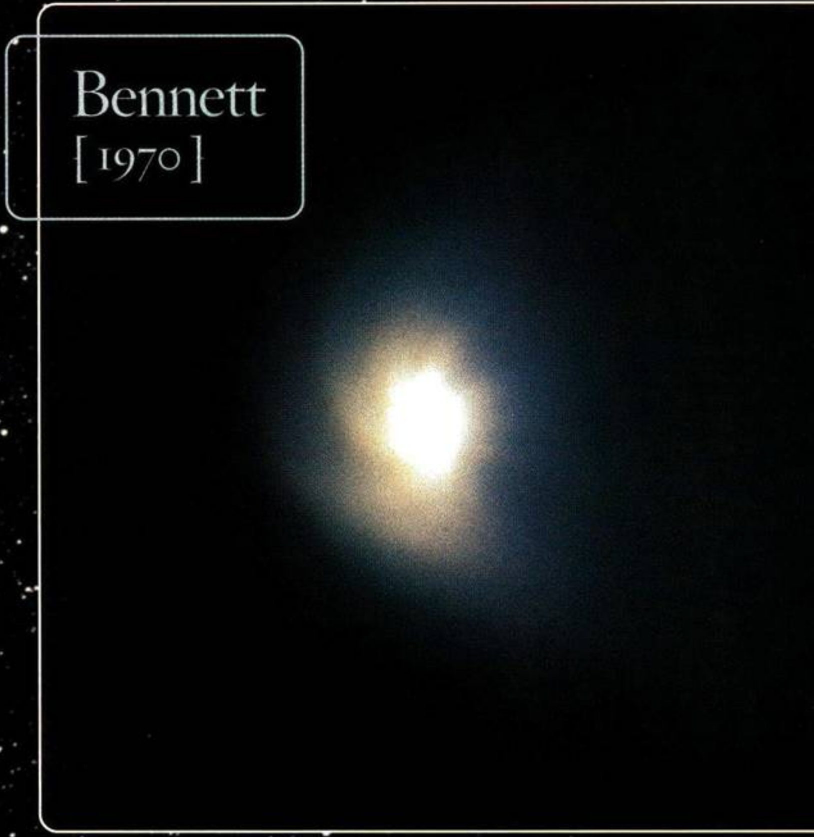
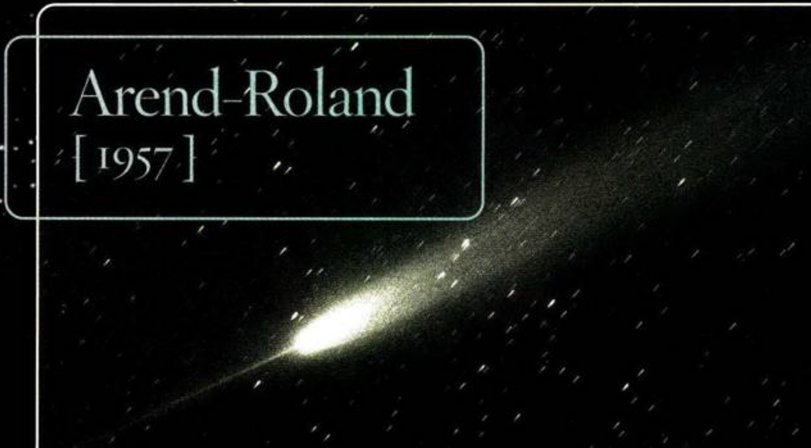
Not long ago, Hale-Bopp and Hyakutake reminded us how spectacular a comet can be. Yet these two cosmic visitors represent only a few of history's great comets.

/// BY RICHARD TALCOTT

Great comets







COMET HALE-BOPP (left) was a greater comet than Hyakutake for city-dwellers because its curving dust tail stood out brighter in light-polluted suburban skies. RON LUXEMBURG **COMET HALLEY** didn't impress Northern Hemisphere viewers in 1986, but from south of the equator, the story was quite different. ARTURO GÓMEZ/NOAO **COMET BENNETT** gave telescopic viewers a nice look at jets coming from its nucleus. LPL/U. ARIZONA **COMET AREND-ROLAND** displayed an anti-tail of dust — a spike of light pointing sunward. It's an optical illusion created by the viewing geometry. LICK OBSERVATORY

Besides dust, ice, and long tails, comets carry a lot of baggage. To many people throughout history, comets — especially the bright ones termed "great" — have been portents of doom, divine omens of some terrible event gathering above. More recently, however, astronomers have come to view comets of all kinds as potential bringers of life. Laden with water ice and organic compounds, the comets that rained down on Earth early in the solar system's history provided much raw material necessary to give life its start.

Yet the transformation of comets from evil to good remains incomplete — and for a sound reason. Scientists today are aware that comets occasionally make direct hits on planets, causing catastrophic damage. As both givers and takers of life, comets inevitably embody a mixed heritage.

Backyard skywatchers, however, usually worry little about such things and mainly admire the show put on by these ephemeral visitors. This spring promises two bright comets for viewing by amateurs and professionals alike. Comets C/2002 T7 (LINEAR) and C/2002 Q4 (NEAT) should be obvious, naked-eye objects that will thrill skywatchers around the world. (See "A tale of two comets" on page 70 for details.)

Yet it appears highly unlikely that either of these comets will rise to the level of greatness. A great comet has the capacity to spellbind jaded professionals as well as people who rarely glance at the sky. To a typical backyard observer, a great comet reaffirms the dynamic nature of the solar system — and becomes an unforgettable touchstone in a lifetime of skygazing.

What makes it great?

All great comets appear bright and sport distinctive tails. Most reach at least 1st magnitude (about as bright as the more conspicuous stars), and many glow significantly brighter. In earlier times, chroniclers make the task of separating the wheat from the chaff fairly easy — before the 20th century, a majority of the best comets were called simply "the Great Comet of [fill in the year]."

About 15 years ago, astronomer David Hughes of the University of Sheffield in Great Britain compiled a list of great comets stretching back to 1600. His list incorporated previous work by Robert Grant, who, in 1852, looked back hundreds of years at what he termed "remarkable comets."

From the list, Hughes developed a set of characteristics that most great comets seem to possess. Such a comet should have a large and active nucleus, so it can expel a lot of material. It needs an orbit that carries it close to the Sun, so that our star's heat can

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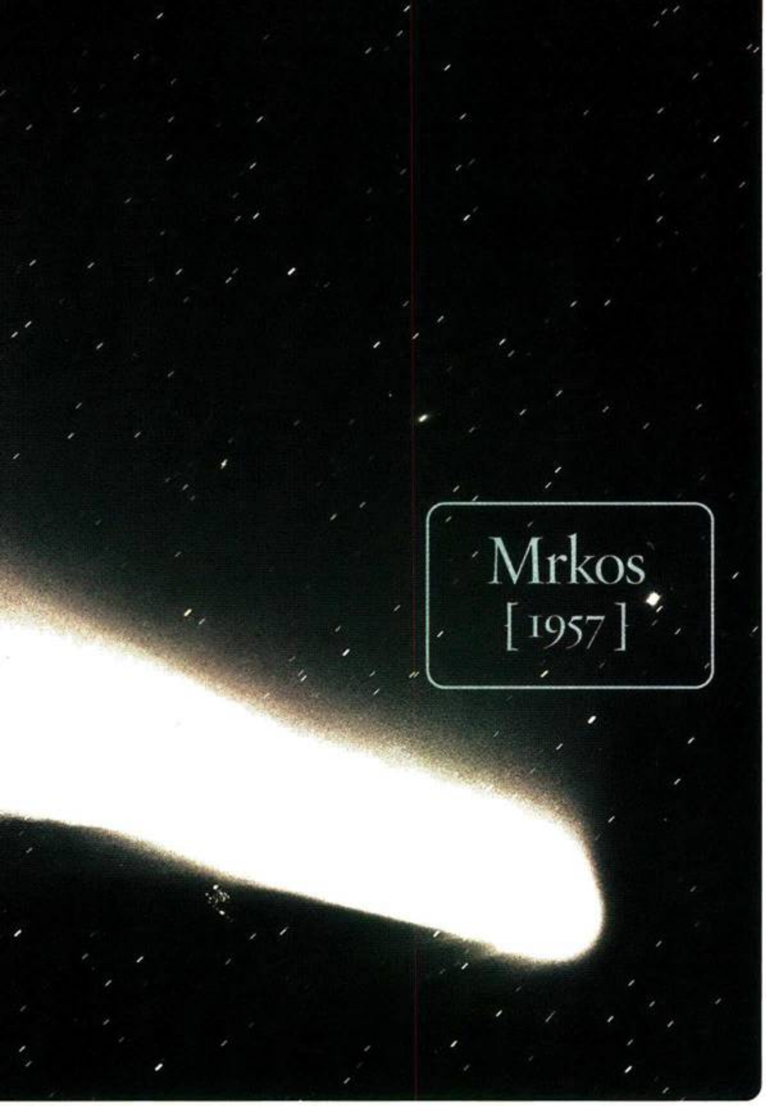
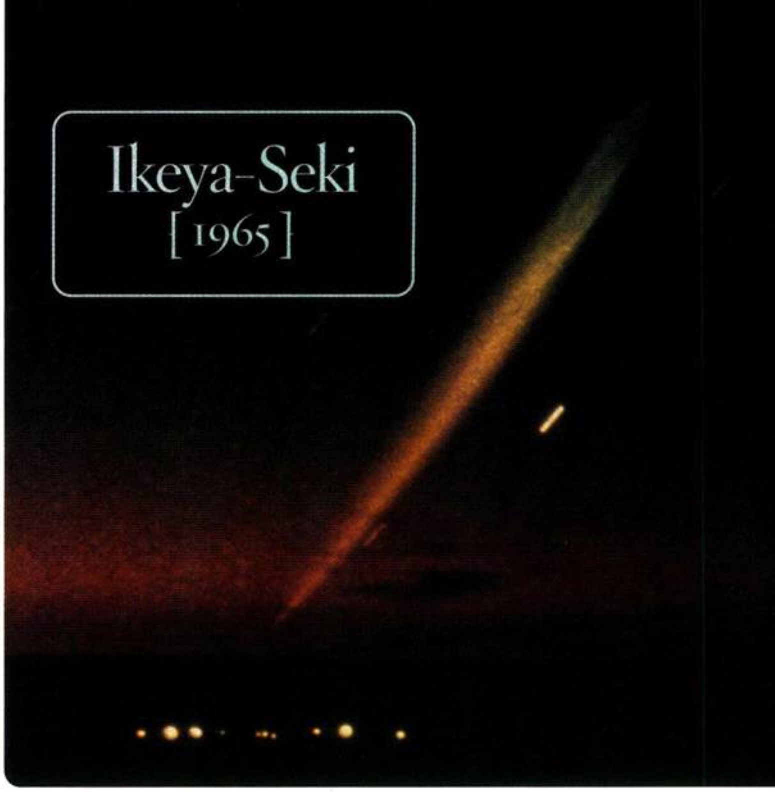
Richard Talcott *is a senior editor of* Astronomy.





COMET IKEYA-SEKI [above] rose out of the dawn in autumn 1965, preceeded by a long tail. Ikeya-Seki belongs to a group of related comets that are all fragments of a much larger comet that broke apart in antiquity. Many non-skywatchers missed this splendid comet because it was best visible at an unfavorable time of day. ROGER LYNDS/NOAO

COMET MRKOS [left] exhibits the two tails that comets display. A smooth tail of dust extends toward the upper left and a more turbulent tail of ionized gas lies below it. The magnetic field in the solar wind, blowing by at hundreds of miles per second, catches the ionized gas tail and makes it flap like a banner. The gas and dust originate in the comet nucleus. ARTURO GÓMEZ/NOAO

cause more of the comet's ices to boil off. The orbit must also bring the comet close to Earth, so it appears bright. In addition, it helps if the comet remains bright for an extended period, its tail grows long, and it provides good viewing opportunities for observers on Earth.

On average, about 13 comets each century reach the level of greatness, or approximately one every seven or eight years. But this figure is just an average, and great comets appear randomly (not counting the periodic returns of Comet Halley). Comets Hyakutake and Hale-Bopp came just a year apart, but twenty years separated Hyakutake from the previous great comet. And in a statistical fluke, 1910 and 1957 each saw two great comets.

The 20th century's best

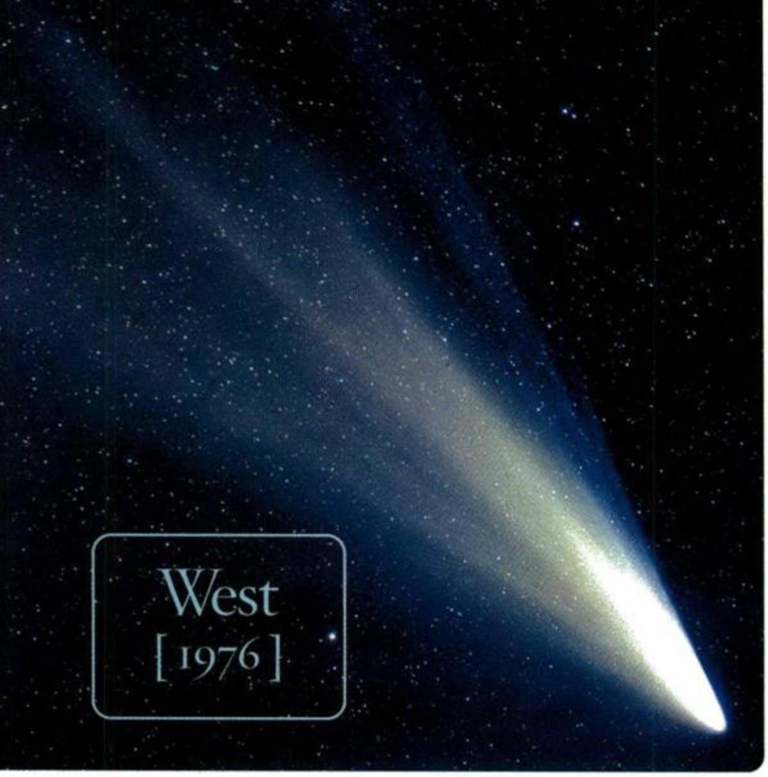
The 1900s came in right on average with 13 great comets, and the first arrived in the first few months of the century. The **Great Comet of 1901** reached prominence in April and remained visible to the naked eye for six weeks. It peaked at around magnitude –2, about as bright as the planet Jupiter typically appears, on April 24. That's when the comet reached perihelion, its closest approach to the Sun. By early May, it sported two distinct tails: a 30°-long straight tail composed of gas and a 10°-long curved tail consisting of dust. Unfortunately, this bright comet remained so far to the south in the sky that only observers in the Southern Hemisphere were able to see it.

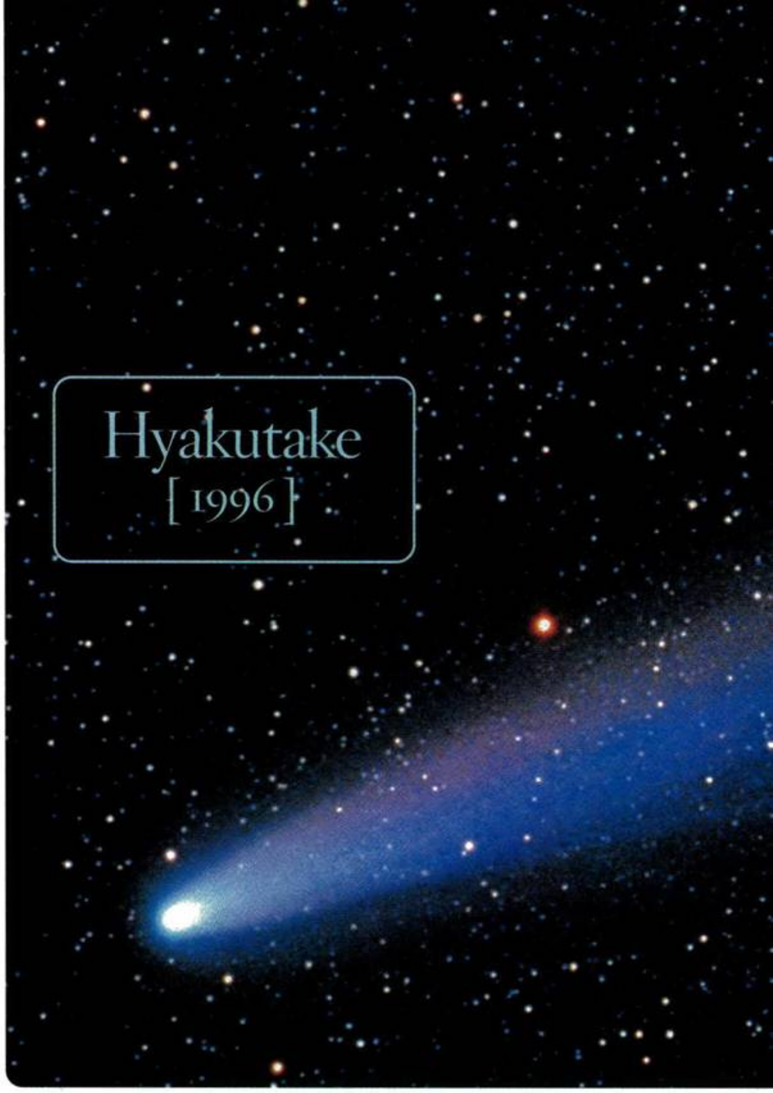
Two great comets graced the skies in 1910. One was the best known comet of all — but the other put on the better show! **Comet Halley** (see page 37) made its first appearance since 1835, reaching perihelion on April 20. It appeared best in May, shining at magnitude 0 and with a dramatically long tail. Halley passed between the Sun and Earth on May 18, when its tail stretched 120°, fully two-thirds of the way across the morning sky.

Despite its impressive appearance, Halley ranked only second-best that year — the **Great January Comet** of 1910 was actually better. It could be seen during daylight between January 17 and 19, when it peaked at magnitude –5 (brighter than the planet Venus). Within a few days, it shone brilliantly during evening twilight with a tail about 10° long. As it faded over the next two weeks, its tail grew longer.

In the year Charles Lindbergh flew solo across the Atlantic Ocean (1927), **Comet Skjellerup-Maristany** made its claim for immortality. In mid-December, it appeared so bright (magnitude –6) that it could be seen in broad daylight next to the Sun. It remained a nice morning object into January 1928, although it could be seen only from the Southern Hemisphere.

Another great Southern Hemisphere comet appeared in 1947, if only briefly. Never receiving a proper name, it was discovered on December 7, already at magnitude 0 or brighter and showing a tail more than 20° long. The comet faded rapidly after that, however, and fell below naked-eye visibility by December 25.





COMET WEST [above] followed on the heels of a not-great comet [Kohoutek] widely seen as a flop. [Scientists, however, got a lot from Kohoutek.] Thus when West arrived and looked like it was going to be bright, astronomers were leery of raising public expectations. In spring 1976, it was a super sight for those who ventured out before dawn to see it. RONALD ROYER AND STEVE PADILLA

COMET HYAKUTAKE [right] was discovered in early 1996 and became a spectacular sight shortly afterward. Seen from a dark-sky site, its gas tail extended across much of the sky. While Hyakutake was not a big comet intrinsically, it came close to Earth, which gave it a lot of the magnificence that indelibly struck everyone who saw it. BILL AND SALLY FLETCHER

The **Eclipse Comet** was discovered during the total solar eclipse on November 1, 1948. It then lay just 2° southwest of the Sun and shone at magnitude –2. The comet had faded slightly by the time it reappeared in morning twilight three days later, again visible only from the Southern Hemisphere. Its 20°-long tail grew another 10° by the middle of November.

Northern winners

The first great comet since Halley for northern observers came in 1957. **Comet Arend-Roland** (see page 37) peaked after the middle of April, when it shone around magnitude 0 and displayed a tail spanning some 30°. But the most remarkable aspect of its appearance came between April 20 and early May, when it developed an "anti-tail" up to 15° long. An anti-tail is a spike of light that appears to point toward the Sun instead of away from it.

Comets have two tails, although either may be invisible to the eye. One tail consists of ionized gas, looks bluish in color, and points away from the Sun, being blown out like a banner by the solar wind. The other tail, which often curves and appears yellowish in color, is made of dust pushed away by the pressure of solar radiation. Arend-Roland's anti-tail was a dust tail, and the geometry of the Sun, Earth, and comet coincided to make it appear to point sunward.

A bare four months later, **Comet Mrkos** (see pages 38–39) occupied the same position Arend-Roland had in the northwestern sky after darkness fell. Mrkos peaked at 1st magnitude during late July and early August. By then it sported two tails, with the brighter dust tail curving prominently.

A few years later, a comet appeared that was arguably the most brilliant of the century: **Comet Ikeya-Seki** (see page 39). This 1965 comet grew bright because it skimmed within 300,000 miles of the Sun's surface at perihelion on October 21. For several days around then, it shone at magnitude –5 and could be glimpsed near the Sun during daylight. Several observers in Japan estimated its brightness within a few hours of perihelion at magnitude –15, brighter than the Full Moon. In late October and early November, Ikeya-Seki displayed a long, bright tail as it rose before dawn.

Comet Bennett (see page 37) put on a grand show in March and April 1970. It reached a peak brightness of magnitude 0 in the morning sky during late March, when it was far enough from the Sun to appear spectacular in a dark sky. Seen through a telescope, its most conspicuous features were jets of material ejected from the nucleus that spiraled into the tail.

In 1976, **Comet West** (above left) took a different path to greatness. As it passed perihelion in late February, its nucleus split into four pieces. This exposed fresh material to sunlight, rapidly increasing the comet's outgassing and causing it to brighten by about four magnitudes. A few days past perihelion, West glowed at magnitude –3. It then moved into the morning sky, where it exhibited a huge tail featuring several distinct components.

Twenty years passed before another great comet arrived. To many, 1996's **Comet Hyakutake** (see above) ranks as the finest of the century. It peaked in late March at magnitude 0. But what set this comet apart was its immense gas tail and ideal location for Northern Hemisphere observers. It passed near Polaris, the North Star, remaining visible all night. At maximum, the tail stretched across nearly 100° of sky. Not an intrinsically bright comet, Hyakutake owed its greatness to coming within 10 million miles of Earth. That's what made it bright and gave it such a long tail.

Just a year later, **Comet Hale-Bopp** (see page 36) stood at the top of the heap. Peaking at magnitude –1 in April 1997, it showed a straight, blue-tinted gas tail 25° long plus a curving, yellowish dust tail about as big. Hale-Bopp could be seen without optical aid for 15 months — from July 1996 to October 1997 — a record for any comet. Hale-Bopp violated two of David Hughes's criteria: it came close to neither Earth nor the Sun. Yet the comet more than made up for these deficiencies by being very large and active. Its nucleus measured about 25 miles across, giving it a surface area some six times that of Halley and more than a hundred times that of Hyakutake. Great size allowed Hale-Bopp to release huge amounts of gas and dust, even far from the Sun.

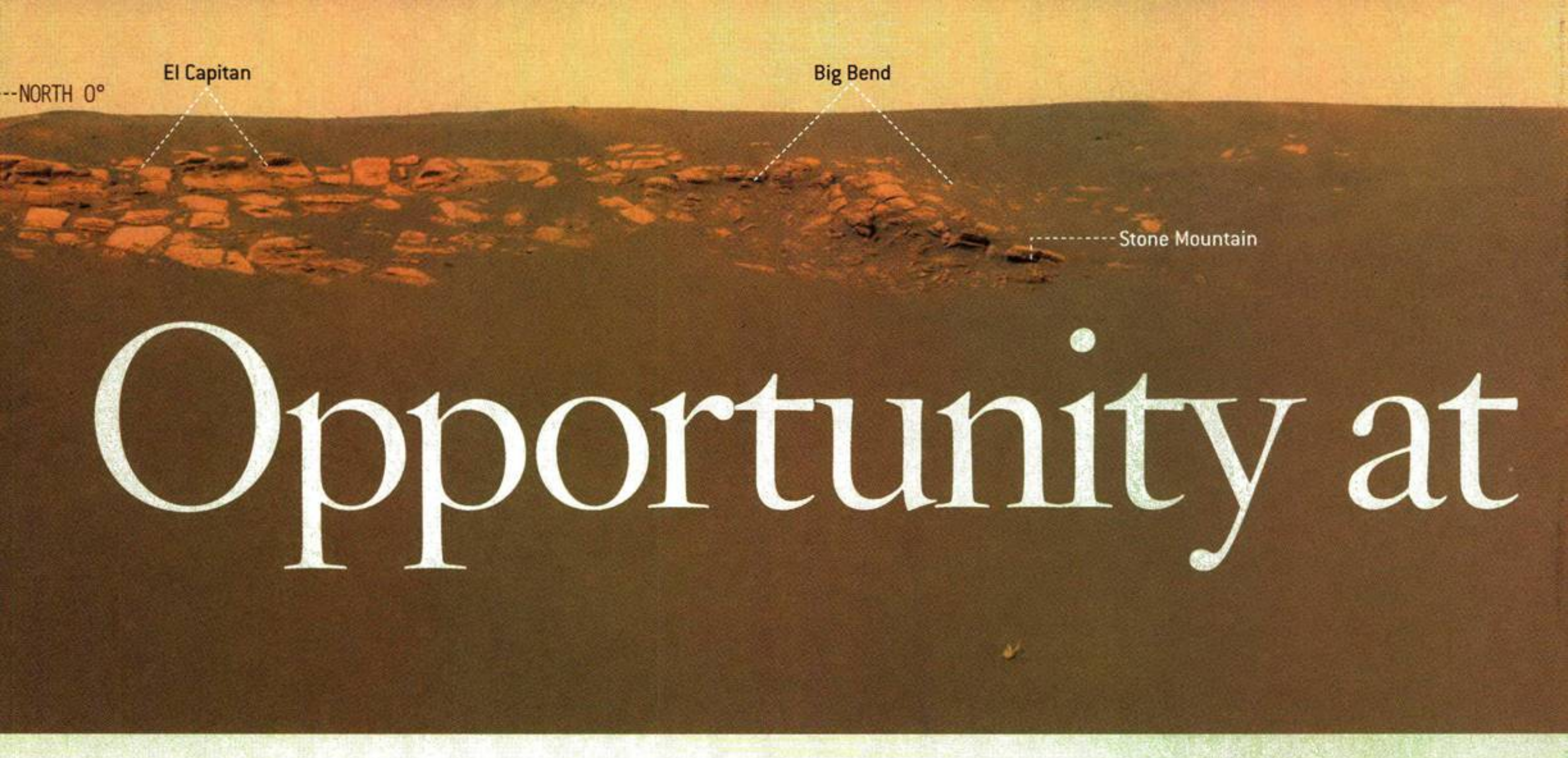
Into the past

Comet observing did not begin in 1900, of course. Great comets have been arriving in the inner solar system as long as Earth has been around, yet early records are often scanty and sparse. While observations have improved over time, a complete census of great comets probably can be extended back only 400 years or so.

Within that time frame, the 19th century seems to hold the high-water mark, with 19 recorded great comets. These include perhaps the greatest great comet ever seen: the **Great September Comet** of 1882. Sailing very close to the Sun at perihelion on September 17, the comet stood out easily to the naked eye at noon — while located less than a degree from the Sun — and sported a tail about 3° long. To be seen this easily, it must have shone near magnitude –17. Its nucleus apparently broke apart around perihelion, which helped it remain brilliant well into October with a long, exceedingly bright tail.

When should we expect the next great comet? It's been seven years now since Hale-Bopp was at its best, so some would say we're about due. Unfortunately, it doesn't appear that either of this year's bright comets will reach "great" status. And as history has taught, the wait is highly unpredictable — it can range from a few months to several decades. But somewhere out in the depths of the solar system, a modest-size lump of ice and dirt is heading our way. One of these days, it will blaze across the sky, taking its place as the latest great comet. Stay tuned. . . . ▣

To learn more about some of the great comets of the past, visit www.astronomy.com/toc



Opportunity at

NASA's second rover, Opportunity, landed at a site that turned out to have been "drenched in water," as one scientist put it. It was once so wet and warm there as to be habitable. /// BY ROBERT BURNHAM

"We're getting a bouncy signal. . . ." The voice was Rob Manning's, the flight controller in charge of Opportunity's atmospheric entry, descent, and landing. It was tight with tension. Then, moments later, with triumph: "We're on Mars, everybody!"

Swaying beneath its parachute and cocooned in airbags, NASA's Mars Exploration Rover Opportunity fell through a cold, tan-colored sky to a perfect landing on Meridiani Planum. The landing site lies 2° south of the martian equator and 6° west of the planet's prime meridian. The touchdown occurred on schedule at about 1:30 P.M. local Mars time — back on Earth it was 9:05 P.M. (PST) on January 24, 2004 — and delivered the second rover spacecraft in three weeks to the martian surface.

Opportunity's mission was to examine a region known from orbital studies to be rich in hematite, an iron-oxide mineral that often forms in association with water. Opportunity and its twin rover, Spirit (see "Spirit lands at Gusev," April 2004), were sent by scientists in hopes of finding places that may have once contained ample quantities of liquid water, either as standing water or in hydrothermal systems. This, they feel, is the key to locating where life may have existed on ancient Mars. Once identified on the ground, such places could be revisited with more sophisticated probes that would either make on-site analyses or snatch up samples to return to Earth for study in terrestrial laboratories.

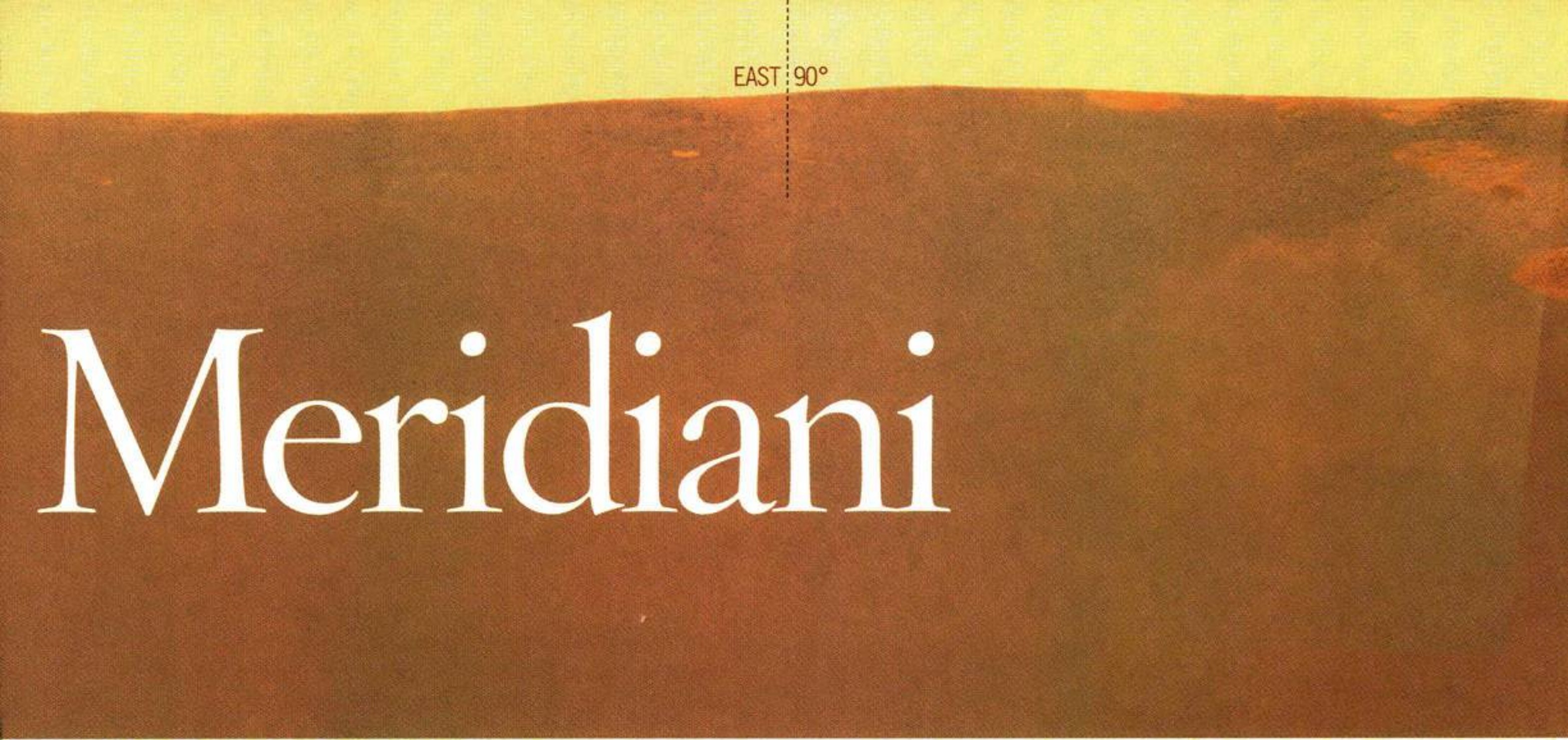
Rust on the plain

Opportunity's landing site lies in a part of Meridiani Planum with relatively little topographic relief. The land slopes very gently northwestward away from the highlands surrounding the ancient impact basin Hellas, which lies 3,300 miles (5,300 kilometers) to the southeast.

Meridiani contrasts with Gusev Crater, Spirit's landing site on the other hemisphere of Mars. Gusev is a basin in which water probably pooled or flowed through for a long time. Meridiani — at least the part where Opportunity set down — appears quite flat and generally featureless. So why go there?

From a mission-safety point of view, Meridiani posed less risk than Gusev. Orbital surveys by the Mars Global Surveyor (MGS) and Mars Odyssey spacecraft told scientists that the Meridiani site

Meridiani



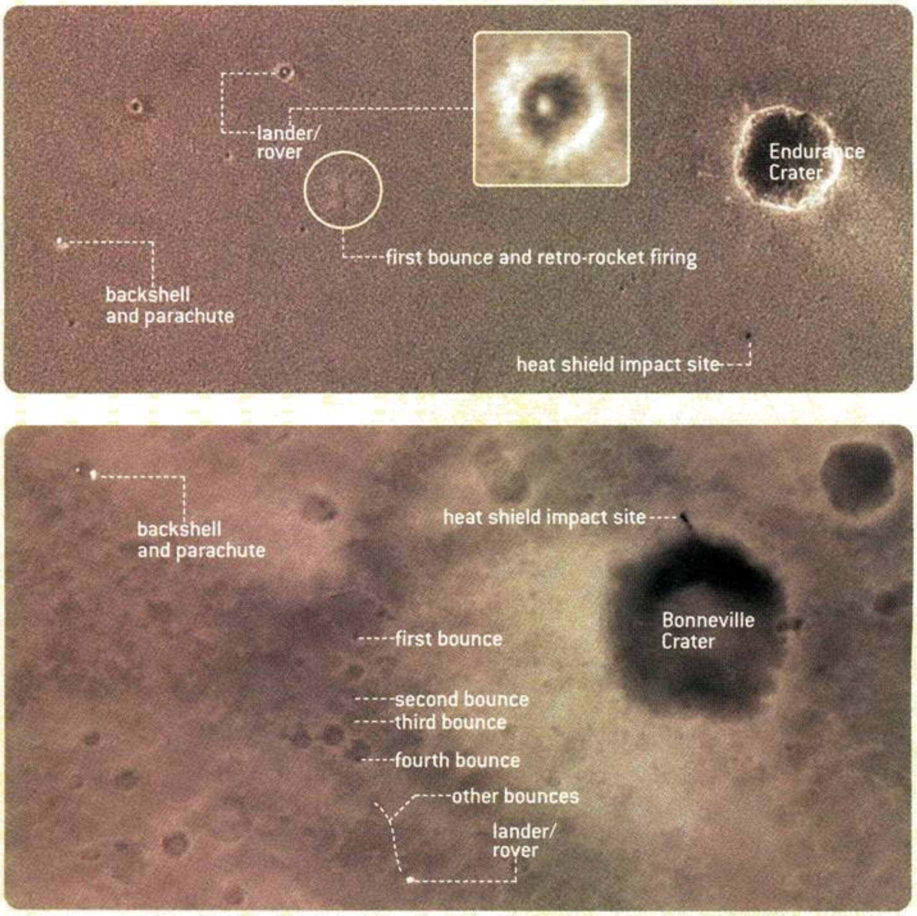
LANDING IN A CRATER, Opportunity took a 360° panorama (continuing on the next four pages) showing an outcrop of bedrock just 30 feet away. NASA/JPL

was largely free of dust (which could trap a rover) and boulders (which might block its path or tip it over). The surveys also identified large concentrations of hematite there. This iron-oxide mineral can form in lakes; it can also form at warmer temperatures by the accelerated weathering of volcanic materials. In the first case, hematite would indicate a lot of water, while the latter would suggest less of it.

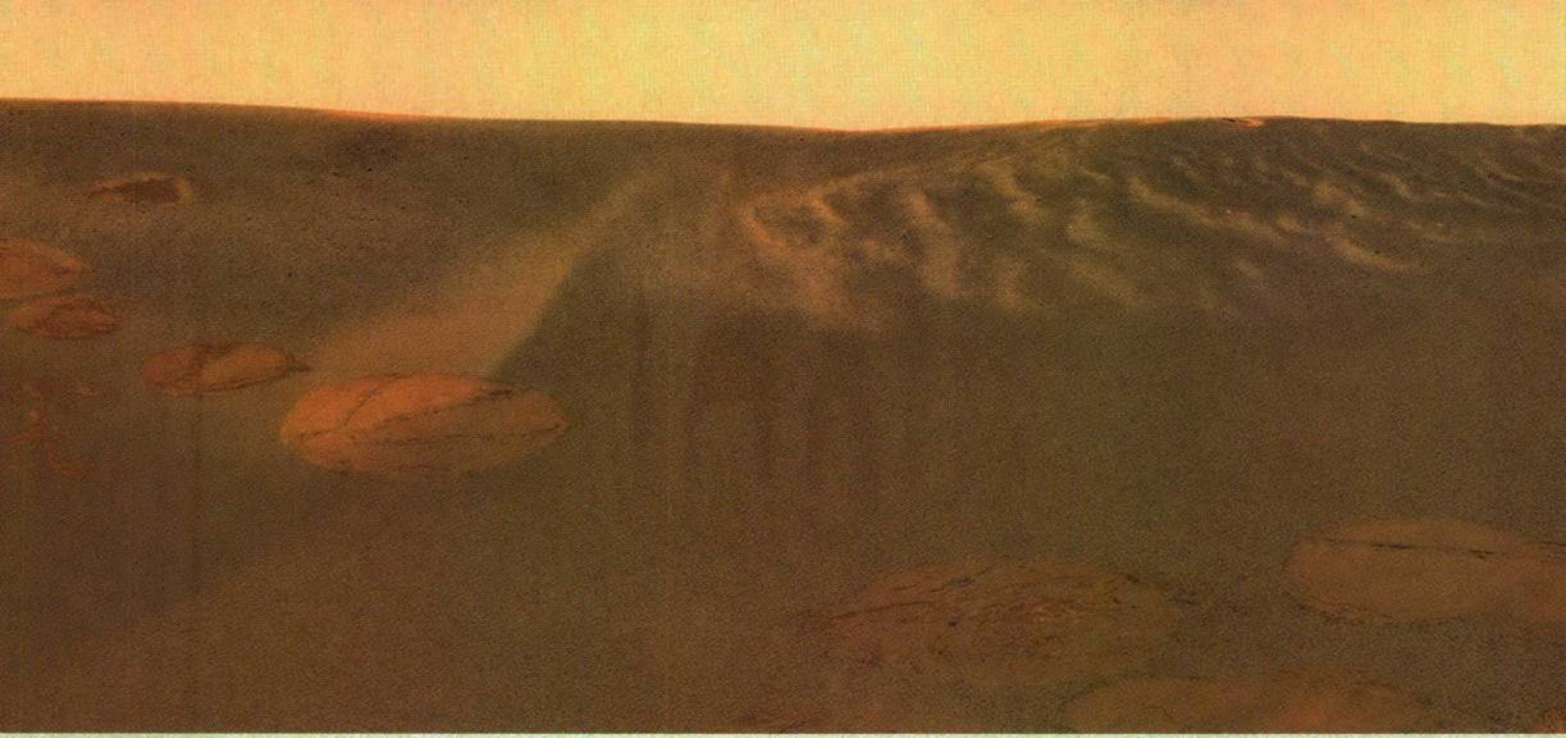
Opportunity tumbled to a halt inside a 72-foot- (22 meter) diameter shallow crater, making what rover principal investigator Steve Squyres called, "an interplanetary hole-in-one." When the rover looked around, delighted scientists saw a long outcrop of light-colored bedrock barely 30 feet (10 m) away that wrapped around a third of the crater. Although the outcrop looked imposing in the rover's initial photographs, measurements showed it was less than a foot (30 cm) high in most places.

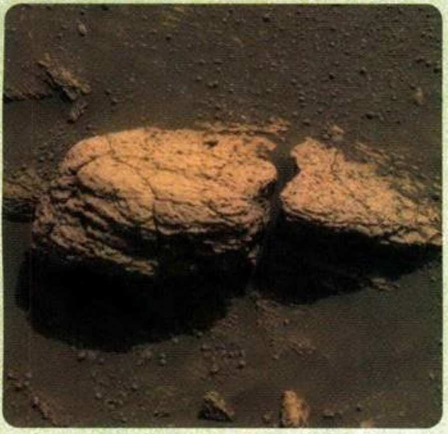
The outcrop showed thin layers, many about half an inch (1 cm) thick. Such structure is characteristic of sedimentary rocks, whether they were deposited underwater, as windblown dunes, or in the form of volcanic ash settling out of the air. The outcrop also showed what may be two main units, one with thinner layers and another with more-thickly bedded ones.

Geologists love bedrock exposures because the rock hasn't traveled anywhere.


lander/
rover
Endurance
Crater
first bounce and retro-rocket firing
backshell
and parachute
heat shield impact site
backshell
and parachute
heat shield impact site
Bonneville
Crater
first bounce
second bounce
third bounce
fourth bounce
other bounces
lander/
rover

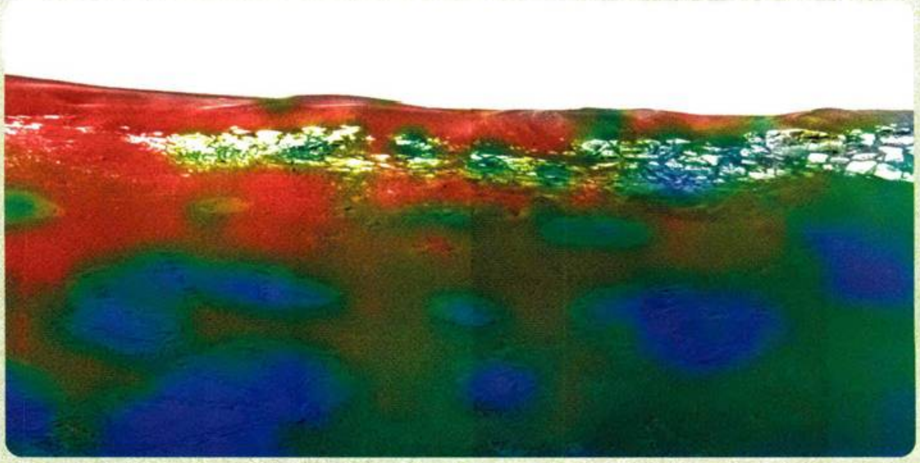
OPPORTUNITY KNOCKED ON MARS (top) and left signs of its arrival in the landscape. The inset photo shows Opportunity's lander resting in the 72-foot-wide crater it rolled into. Compared to Spirit's landing site in Gusev Crater (below), Opportunity set down in a part of Meridiani Planum that looks almost featureless. Both images were taken from orbit by the Mars Global Surveyor. MSSS/NASA/JPL





STONE MOUNTAIN was targeted by scientists eager to see where hematite-rich spherules come from. See detail at right. NASA/JPL/CORNELL

ZOOMING IN on Stone Mountain shows a spherule weathering out of the sediments. Such beads formed in the rock around impurities. NASA/JPL/CORNELL



RED TINTS INDICATE HEMATITE seen by Opportunity's mini-TES instrument. The rover's airbags flattened the blue patches in the foreground, driving hematite-bearing pebbles into the soil. NASA/JPL/CORNELL

It formed just where it's found, and if geologists can determine the rocks' nature and origin, they can unfold the history of one part of Mars, however small.

The surface around Opportunity appeared a lot darker and redder than the tawny dust and sand surrounding Spirit. Also, the ground in Meridiani had a granular texture that was crushed smooth where the rover's airbags rolled across it. When scientists examined Opportunity's vicinity with the rover's mini-thermal emission spectrometer (mini-TES), they found abundant amounts of hematite. Spectra from the mini-TES helped scientists decide that although they couldn't exclude a volcanic origin for the hematite, more likely it had formed by relatively low-temperature methods involving water.

However, the flat spots in the soil caused by the airbags showed no hematite, leading scientists to think that the mineral was concentrated mainly in tiny particles about the size of BBs. These were driven into the soil by the airbags' weight, thus erasing the surface traces of hematite.

Exploring an outcrop

When Opportunity rolled over to the outcrop some two weeks after landing, it began at the northeastern end with a feature named Stone Mountain. There, the rover's camera detected loads of beads

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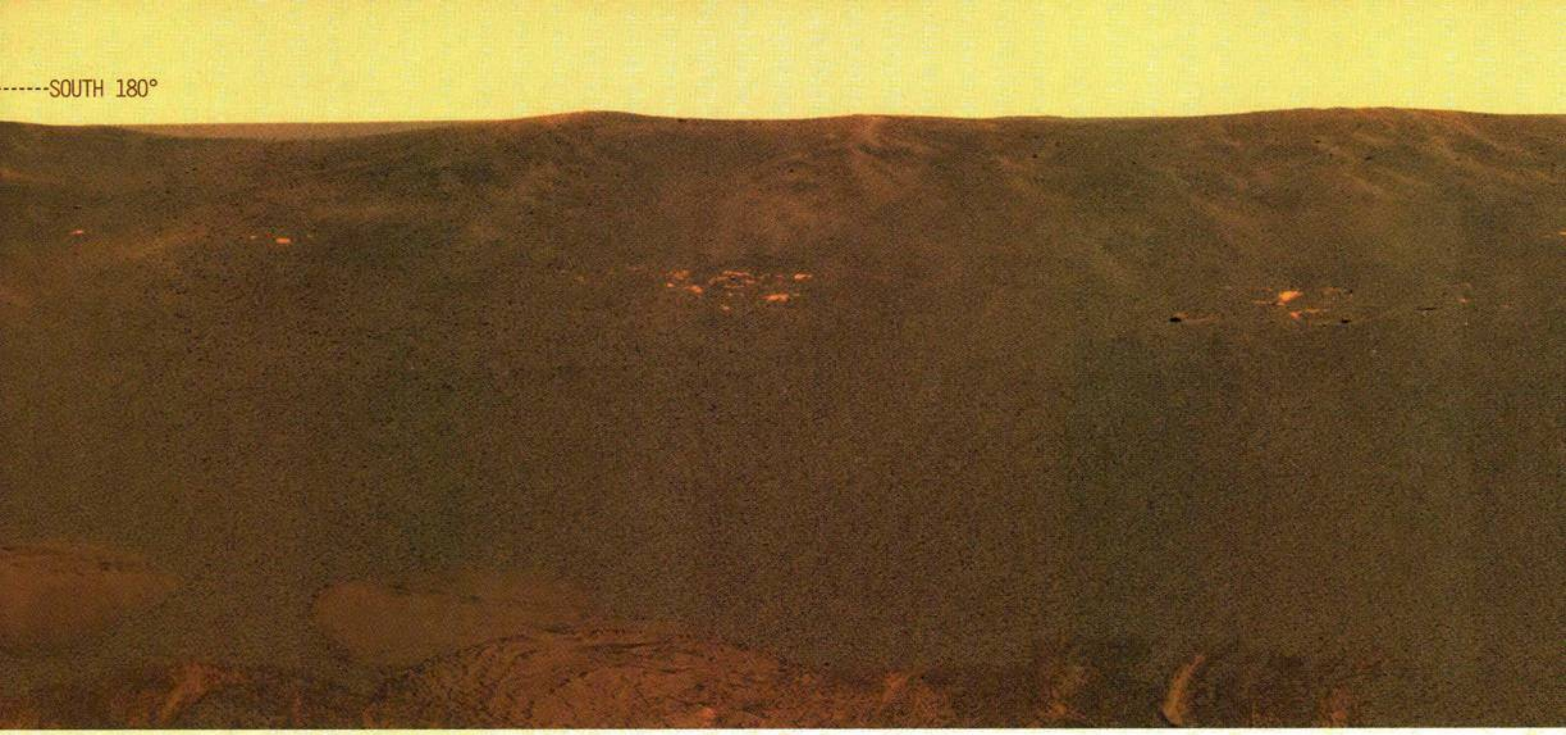
Robert Burnham *is a senior editor of* Astronomy.

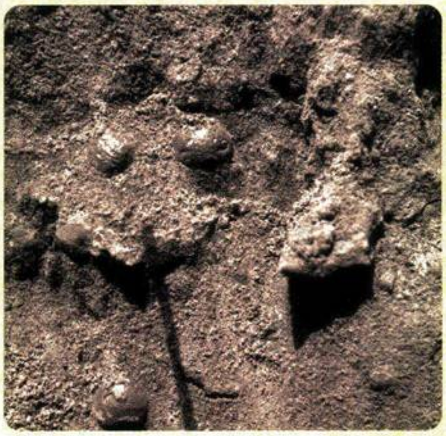


similar to those found in the soil; they seemed to be weathering out of the rock. A close-up image even showed one pebble hanging from the layered sediments.

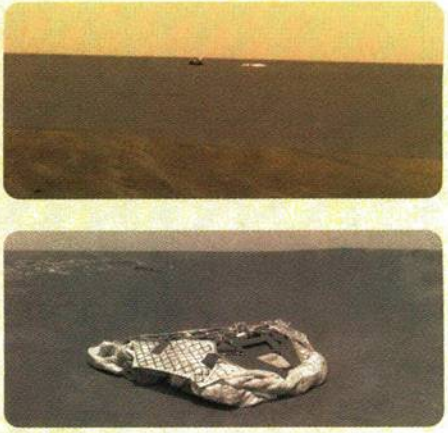
As the scientists looked for clues about what made the spherules, nicknamed "blueberries," Opportunity's alpha particle X-ray spectrometer found that the outcrop contains more sulfur than any rocks ever seen on Mars before. At the same place, the Mössbauer spectrometer detected jarosite, a hydrated iron-sulfate mineral.

Were the sediments laid down underwater? The sulfur provided an excellent clue, and it pointed toward a wet — indeed very wet — origin for the rocks seen in the outcrop. Their exact formation mechanism remains uncertain still, however. Based on the rover observations, scientists suggest that the sediments may be compacted layers of volcanic ash littered with drops of molten rock, either volcanic or impact-melt, that cooled into spherules; or wind-blown dust (or ash) that was soaked by water and hardened into rock; or layers that precipitated at the bottom of a standing body of water.

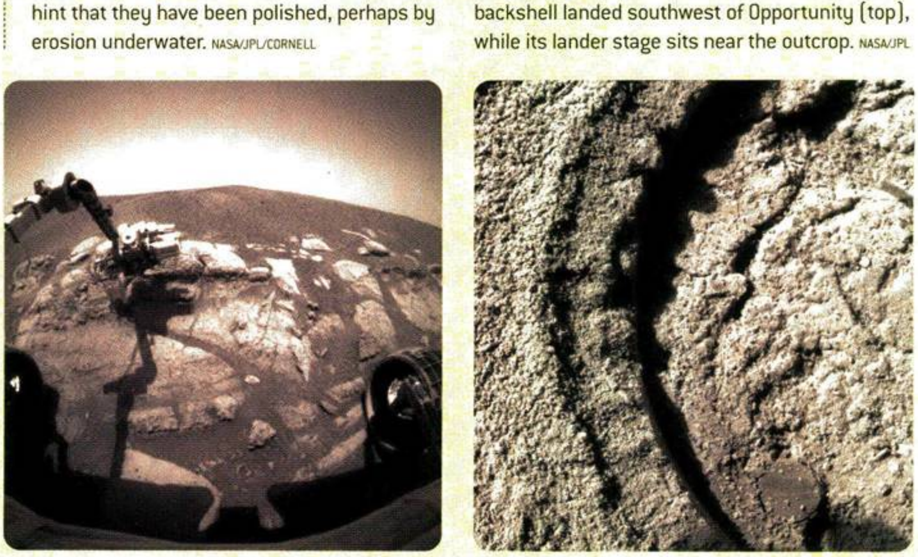
In any case, scientists were excited to see the rocks' high sulfur content, which takes the form of magnesium sulfate — more commonly known as Epsom salts. The salt makes up about 40 percent of the outcrop rocks' composition. Such a substance can form only in places that are "soaked in water," in Steve Squyres' words.



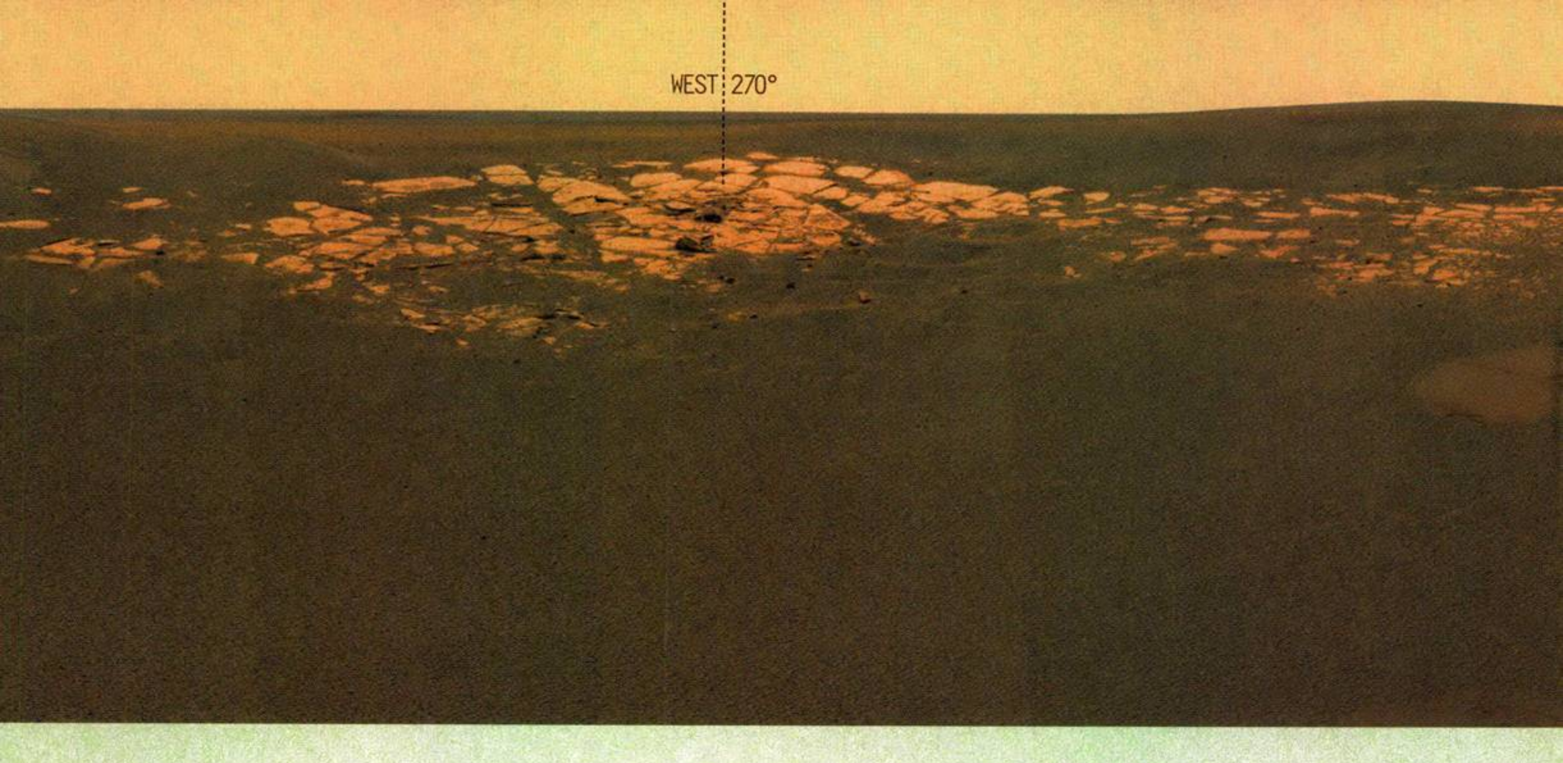
SHINY SPHERES in the sticky soil of Meridiani hint that they have been polished, perhaps by erosion underwater. NASA/JPL/CORNELL

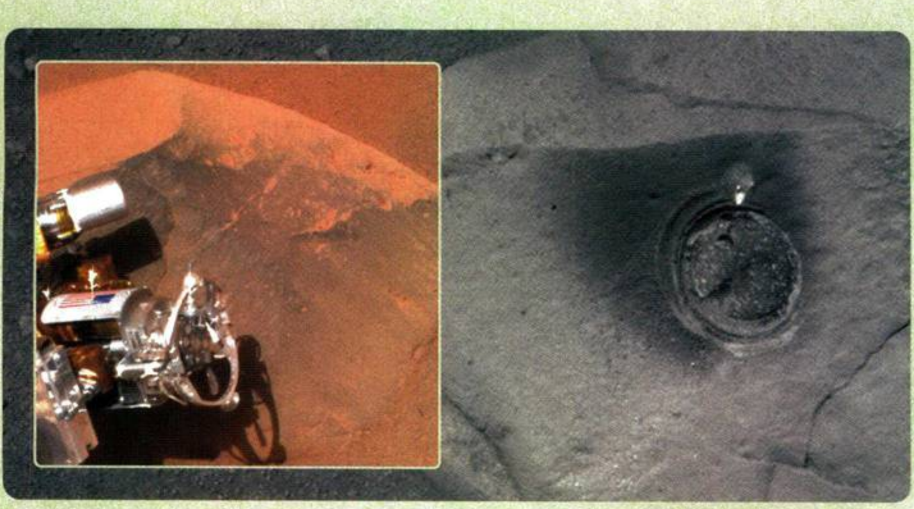


LITTERING MARS: The white parachute and dark backshell landed southwest of Opportunity (top), while its lander stage sits near the outcrop. NASA/JPL



AT EL CAPITAN, Opportunity placed the rock-abrasion tool (RAT) on the outcrop (left). The RAT cut a 2-mm spherule in half (right, bottom) while exposing voids within the rock texture. NASA/JPL/CORNELL





BACK AT WORK, Spirit dug into Adirondack rock, picking up the mission where it stalled when the rover had memory problems. At right, the mark of the RAT scars the basaltic rock. NASA/JPL/CORNELL

FLAKY MIMI rock gave promise of a sedimentary nature, yet when analyzed by Spirit, it proved to be ordinary basalt. NASA/JPL/CORNELL

AT CHARLIE FLATS, Opportunity imaged a coffee-table-size area, finding pebbles, rocks, and soil with a great diversity of types. NASA/JPL/CORNELL

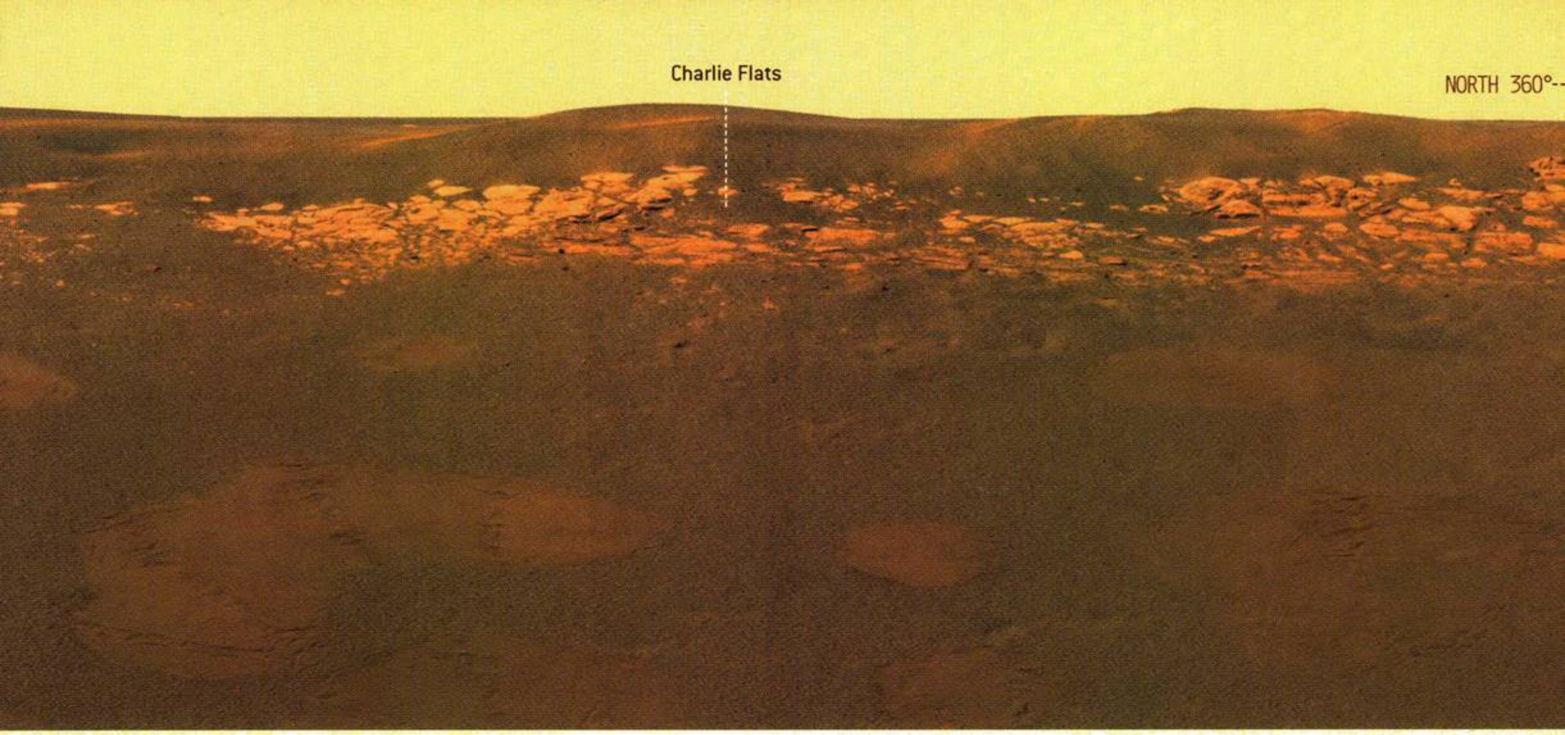
The spherules appear most likely to be what geologists call concretions. These are beads that form around chemical impurities within a rock layer when water permeates it. The beads might form as water wraps the grains in layers of minerals, much the way an oyster makes a pearl.

After Stone Mountain, Opportunity moved south along the outcrop toward a feature called El Capitan. Before reaching it, the rover dug a trench 4 inches (10 cm) deep with one wheel. The rover's microscopic imager found spherules in the soil with shiny surfaces that may have been produced by the action of water.

At El Capitan — which, despite its grand name, is about as high as a street curb! — the rover scrutinized the outcrop with its Mössbauer spectrometer and alpha particle X-ray spectrometer. Then the rover unlimbered its rock-abrasion tool (RAT) to grind "RAT holes" in the layers at the top (named Guadalupe) and bottom (named McKittrick) of the outcrop.

When the microscopic imager zoomed into the RAT holes, the scientists found small voids (called vugs) in the rock's internal fabric. These resemble what happens when mineral crystals form within a rock and are removed from it later, perhaps being dissolved by water — again suggesting that the Meridiani site has seen lots of water in a warmer martian past.

"This place would have been habitable," declared Squyres, explaining that terrestrial



organisms could have lived there — while adding the caution that the rover's instruments saw nothing to suggest that martian life *had* dwelled there.

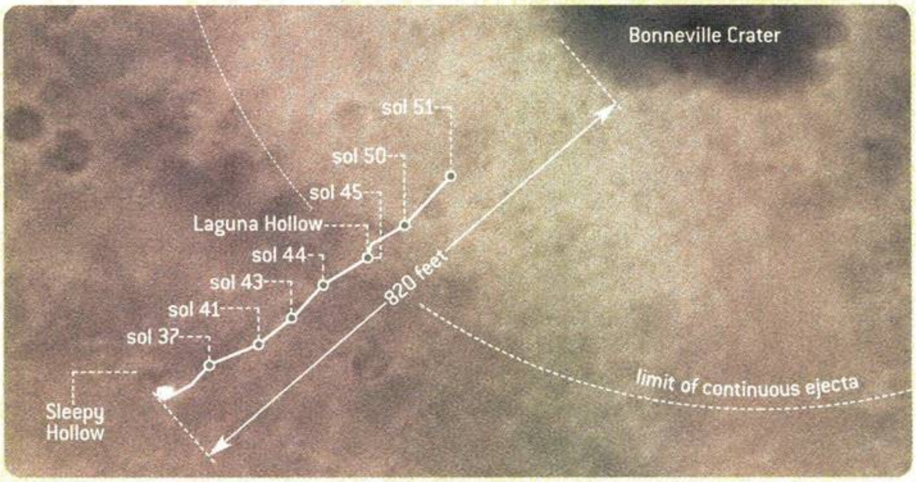
The next step for Opportunity is to finish its survey of the crater, looking for clues whether the outcrop rocks were deposited in standing water or were soaked by groundwater percolating into them.

Then Opportunity will drive up and out to explore the surrounding plain. In particular, the scientists want to examine Endurance Crater, which is about 520 feet (160 m) in diameter and lies 2,300 feet (760 m) away to the east. They want to see if the outcrop's rocks turn up in this crater.

Meanwhile, back at Gusev

Soon after Opportunity landed, flight engineers got the stalled Spirit rover back to work by resetting its flash memory. Now, mission scientists are steering Spirit toward the rim of Bonneville Crater on the northeast horizon. This impact crater is about 850 feet (200 m) in diameter and about 50 feet (15 m) deep. Its formation likely dredged up rocks from below the present surface, offering scientists a way to sample hidden layers.

At the rim of Bonneville, scientists will decide if they want to send Spirit down into the crater. It may be able to survey the scene from the rim — and some scientists would like to direct the rover onward, southeast toward the distant hills.



SPIRIT'S ROAD TRIP began among the rocks near the lander. Scientists are hoping that ejecta from Bonneville Crater (top right) contains rocks brought up from deep underground. MSSS/NASA/JPL

ROCKS CLUSTER THICKLY where Spirit enters the ejecta field of Bonneville Crater, whose rim lies on the skyline. Spirit may go down into the crater — or drive southeast toward the hills. NASA/JPL/CORNELL

{ SPACE EXPLORATION }

The new American space initiative will refocus NASA on human exploration. The Moon and Mars beckon, but the toughest part of the job lies in Washington.

/// BY FRANK SIETZEN, JR. ///

A new vision for SPACE

IRONIES CROWDED NASA'S PERILOUS YEAR from February 2003 to February 2004, but one was astounding. An American president with no previous interest in space, along with a NASA administrator with no space-program experience, crafted a policy that space supporters had awaited for nearly four decades.

The nation's 43rd president proposed to return astronauts to the lunar surface within a decade and then prepare them for voyages to Mars and beyond. True space exploration — a human exploration agenda — would once again be the centerpiece of the U.S. civil space program. And everything NASA does would fit that objective, or risk reduction or termination.

The new space policy had been rumored, whispered, and anticipated in Washington space circles for weeks. Now "spacers" had their hopes rewarded with the most ambitious human space-flight plan ever. It would send Americans into the solar system to explore the Moon, Mars, asteroids, and even farther. It would be spacefaring in the classic tradition set more than four decades ago by another president, in another time of national uncertainty and testing.

Man to the Moon invokes an almost mythic resonance in the history of the late 20th century. The clarity of the goal set by President John F. Kennedy — man, Moon, decade — the ultimate success of the Apollo program, and the idea that the Moon-landing era was NASA's golden age have stood in contrast with all the space efforts that followed. By comparison, none of Kennedy's successors had successfully established humans to the Moon or Mars as a national goal. With enthusiasm for advanced space plans cooling, no substantial review of human space-flight goals had been undertaken in more than a decade and a half. But all that changed on January 14, 2004, with a new mandate from the Bush administration.

This initiative, which NASA calls Project Constellation, might be called "Mars by way of the Moon; robots and humans working together; developing exploration technologies." But not only are new program elements and vehicles central to achieving George W.

Frank Sietzen, Jr., *is coauthor of* New Moon Rising: The Making of George W. Bush's Space Vision and the Remaking of NASA, *to be published in June by Apogee Books of Canada.*

THIS VIEW OF EARTH FROM THE MOON galvanized the world in 1968 and provided the keynote for the first manned lunar landings. A new space initiative would return humans to the Moon and prepare them for trips to Mars. NASA

Bush's goals; a thorough transformation of NASA itself will also be required. Adding to the new spacecraft, robots, and tools will be a subtraction of those elements of NASA that the agency will be required to give up — literally, to pay for the Moon.

First finish what was started

To unveil his space-exploration initiative, Bush came to NASA's headquarters in Washington, the first time a sitting United States president had come to the agency's home. Space was important, Bush said: "It is a subject that's important to this administration, it's a subject that's mighty important to the country, and to the world." Noting it had been more than a quarter century since the last American human spaceship had been developed, the president pledged it was time to begin something new.

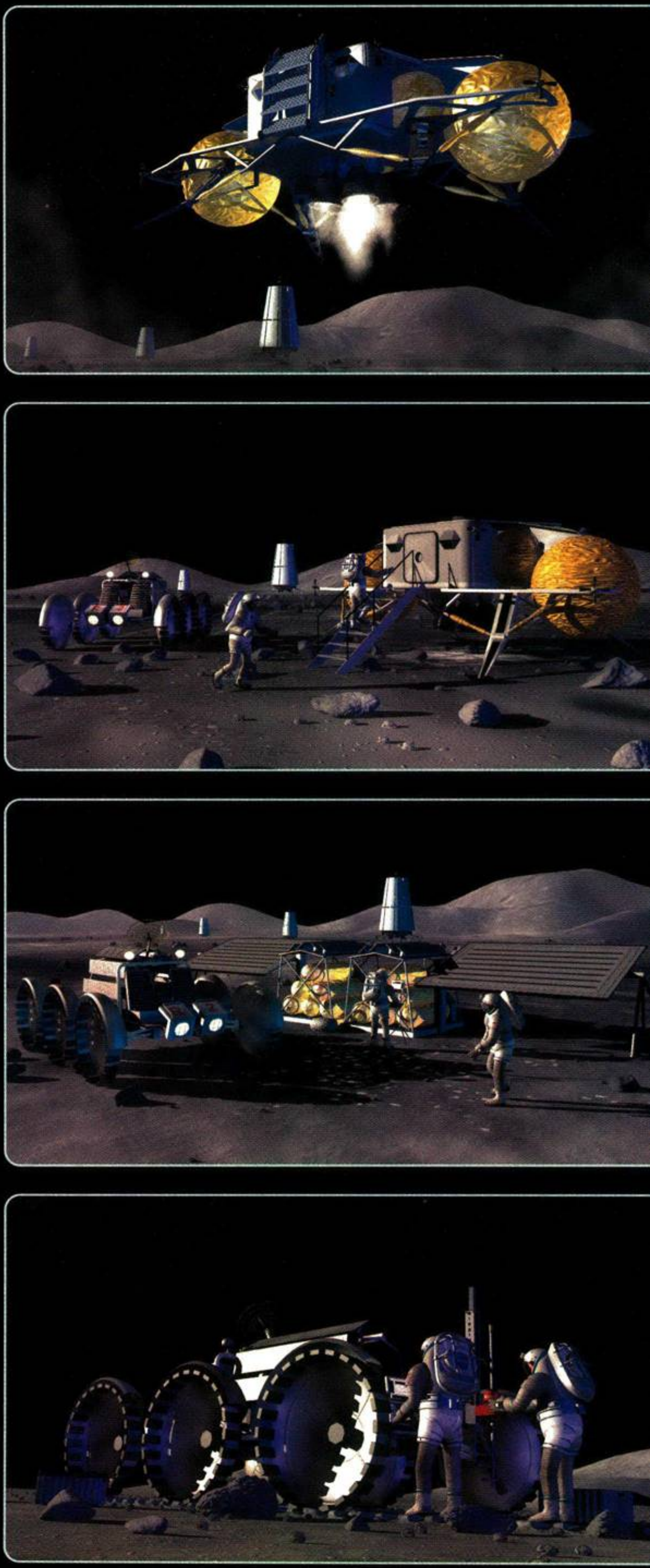
"In the past thirty years, no human being has set foot on another world, or ventured farther upward into space than 386 miles," a distance the president compared to a journey from Washington, D.C., to Boston. "It is time for America to take the next steps," he told the packed audience crowded into the agency's auditorium. "We will build new ships to carry man forward into the universe, to gain a new foothold on the Moon, and to prepare for new journeys to worlds beyond our own," Bush said. Why? "Because the desire to explore and understand is part of our character."

The future in space will begin with the two central elements of the existing U.S. manned space program: the space shuttle and the International Space Station (ISS). The top priority facing NASA is to return the shuttle to operations. Once flights resume, the shuttle will complete the orbital assembly of the International Space Station. "We will finish what we have started," Bush said, and once the station is completed, the fleet of three remaining shuttles will be retired, no later than 2010.

Beginning immediately, all research conducted by the United States using the station will shift to investigating how to sustain humans in space. "Research onboard the station and on Earth will help us better understand and overcome the obstacles that limit exploration," said the president. "Through these efforts, we will develop the skills and techniques necessary to sustain further space exploration."

Project Constellation

In addition, Bush's policy calls for the development of a new exploration-class human spacecraft called the Crew Exploration Vehicle, or CEV. "This will be the first spacecraft of its kind since the Apollo Command Module," the president explained. The CEV could make its first flight in 2008 and perform its first manned landing on the Moon by 2014. More substantial missions will follow, no later than 2020. The goal of the vehicles is to allow astronauts to live and work on the lunar surface for increasingly extended periods. Advanced robots will work with astronauts during their explorations of the Moon. This provides an incremental approach to lunar exploration. "We'll make steady progress — one mission, one voyage, one landing at a time," Bush said.



A MOONBASE COMES FIRST because it offers both important planetary science in itself and a test bed for the Mars expedition. The lunar south pole is a likely site. ILLUSTRATIONS: JOHN FRASSANITO & ASSOCIATES

As with Apollo, robots will pave the way for human missions, with the first new robotic flights to the Moon starting about the same time as the CEV test flights, 2008. New power, propulsion, life support, and other systems that could sustain humans on other worlds will be tested during these lunar visits.

With technologies developed on the Moon, the United States will be ready for human missions to Mars — and worlds beyond.

Buying the Moon

Like the now-canceled Orbital Space Plane, the CEV will ride into space on an expendable launch vehicle, such as a Delta or Atlas or Ariane rocket. No new super-booster like Apollo's Saturn V is envisioned, although a cargo rocket using shuttle hardware is being studied. Industry, and possibly space entrepreneurs, may provide upper stages, space tugs, or propulsion modules.

When the new program was announced, NASA Administrator Sean O'Keefe was quick to say his agency hadn't decided on any specific configuration for the CEV. But many NASA sources say it will be almost certainly some form of space capsule, one version of which could serve as the Moon lander itself. Using existing vehicles and older, proven technology like capsules is aimed at keeping the development cost of the project low.

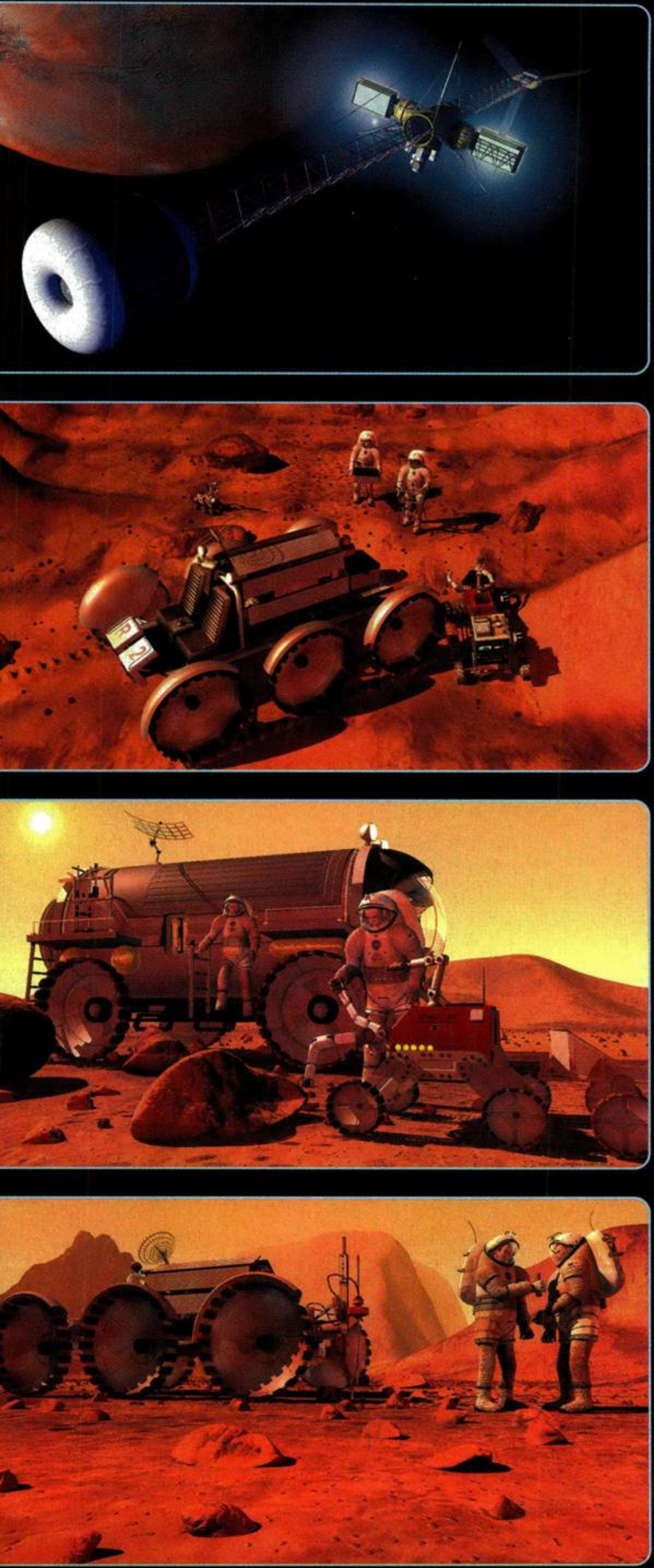
To pay for the initial steps of Project Constellation, Bush proposed to boost NASA's annual $15.5 billion budget by some $800 million next year, and 5 percent more each year for the next three years. Thereafter, the agency would get between 1 and 2 percent additional new funds a year, all devoted to Constellation. Much of the first installment of funding would go to begin development of the advanced robots. But more controversial is an additional $11 billion of existing agency funds that would be stripped from projects like the shuttle and other non-exploration research and redirected to Constellation.

Where all this money will come from, O'Keefe could not say. And after the next decade's research aboard the ISS, the United States will end its heavy use of the orbiting base, shifting focus to the Moon. Between the retirement of the shuttles and the birth of the CEV would lie a gap of two or three years, during which the United States will have no human space vehicle flying. The country will rely entirely on Russian Soyuz craft for lifts into space. By the time the Moon landings are underway, both of today's signature NASA projects, the shuttle and the station, will have ended.

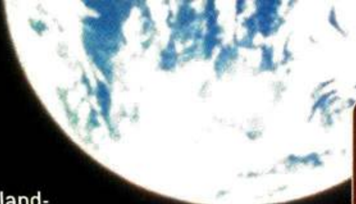
Tough sailing ahead

The most difficult part of crafting a policy isn't the policy itself; it's what follows. Congress, and ultimately the public, must embrace it, a task that history indicates is almost as difficult to achieve as the missions themselves.

A review of the five previous attempts to set national space goals shows stunning achievement and failure. Twice, the efforts yielded the intended programs; twice, the proposals met with substantial revisions in Congress; and one effort failed completely. President Dwight Eisenhower initiated the first American manned space project (called Mercury) in 1959, following the establishment of NASA the previous October. Congress approved the Mercury pro-



EXPLORING MARS WITH ROBOTS will identify locations where life may have existed. But it will likely take human expeditions to settle the age-old question of life on Mars, present or past. ILLUSTRATIONS JOHN FRASSANITO & ASSOCIATES



gram's objective of sending a man into space during the period from 1961 to 1963.

President Kennedy set a goal of landing humans on the Moon during an address to Congress on May 25, 1961. Congress funded the program, and six successful landings were achieved from 1969 to 1972. But public and political support cooled, and three remaining lunar landings, plus a follow-on program to expand the system into semi-permanent lunar bases, were canceled.

On January 5, 1972, President Richard Nixon initiated the reusable space-shuttle program to lower the cost of access to space. But budget cuts imposed from within the Nixon administration and Congress sharply reduced the shuttle from a fully reusable design to today's partly reusable one. That shift reduced short-term costs but led to a more expensive system to run. High operating costs plus delicate hardware have bedeviled the program all along. Instead of lowering launch costs, the shuttle became the most expensive launch vehicle ever, and its fragile design led to a pair of space-flight disasters.

More than a decade after Nixon authorized the shuttle program, another president proposed a new space plan. On January 25, 1984, President Ronald Reagan made building and launching a permanent space station the nation's civil space goal. But Reagan failed to defend the program from critics within his administration as well as from Congressional budget cuts. The station design was altered more than a dozen times while its cost soared from $8 billion to more than $100 billion. The redesigns delayed the completion of the station from "within a decade," as Reagan first sought, to the point where it's still under construction today.

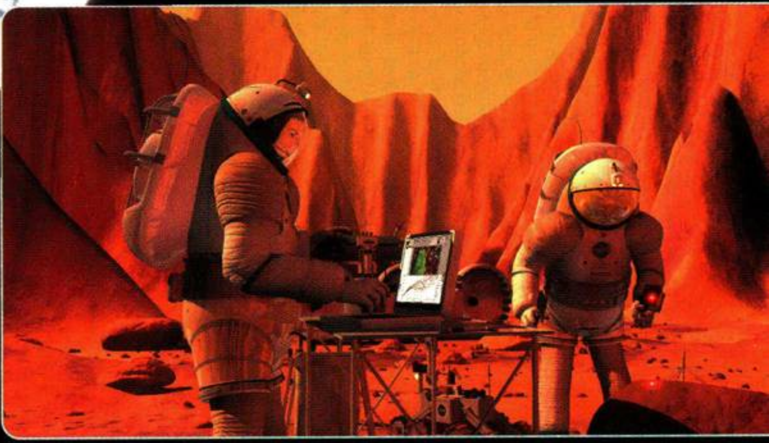
President George H. W. Bush attempted launching his administration's own space goal in a speech on July 20, 1989, the 20th anniversary of the first Moon landing. The elder Bush proposed a program of manned lunar and Mars exploration. But lack of a consensus in his administration, as well as within NASA itself, doomed the plan. Congress failed to fund any element of the proposal, which ultimately was abandoned.

Now the younger George Bush has made his own effort at space planning. He will need to assemble a legislative coalition to start the project with a budget boost in 2005. Each year thereafter, new funding battles must be won to keep the project operating. Between now and the proposed first new landing on the Moon, three presidential elections will occur. Six Congresses will be elected. And the public, whose support will be crucial, will have ample opportunity to have its attention distracted by other issues, few of which can be anticipated today.

The political environment that greets President George W. Bush's space plan today is far different than that which faced John Kennedy's forty years ago. To succeed, Bush will need to forge a consensus not in space but on Earth, among groups that rarely agree on his other policies.

"We have a mandate," said NASA's O'Keefe less than an hour after Bush's announcement on January 14. That mandate is a challenge to achieve. But the hardest challenge of all will be translating it into hardware.

To voice your opinion concerning President Bush's initiative, visit www.astronomy.com/toc



BY MARTIN RATCLIFFE AND ALISTER LING

MAY 04

An observer's dream unfolds on May evenings: several planets line up, the Moon dances with each and with Earth's shadow, and two bright comets punctuate the scene.

The great gig in the sky

One of the greatest seasons in skywatching history is now upon us. You'll want to keep your calendar clear almost every night to soak up the sights. Comet C/2001 Q4 (NEAT) quickly climbs higher into the evening sky and will make headlines if it brightens more than expected. Its deepest impact on the observational psyche will be its conjunction with the Beehive star cluster on May 14 and 15. Develop a plan to get to clear skies if the forecast near you looks discouraging. If you're new to observing and don't have equipment, hook up with a local club through the planetarium in the closest big city.

A LUNAR ECLIPSE on May 4 will deliver 76 minutes of totality to observers in the Eastern Hemisphere with clear skies. JIM BARCLAY

As if one nice comet isn't enough, this month we get two. While Comet C/2002 T7 (LINEAR) puts on a great show for people in the Southern Hemisphere, those in the north see it peek above the morning horizon in early May. It then joins C/2001 Q4 in the evening sky by month's end. For details on observing both comets, see "A tale of two comets" on page 70.

Blazing brilliantly in the west at dusk, Venus reaches magnitude –4.5 on May 2, the maximum brightness during its current evening apparition. Through a telescope, you can see the planet's disk swell and its crescent thin in just a few days. Like the end of a pop-fly in baseball, Venus already has passed its high point in the sky and now is plunging back toward the horizon. In a few weeks it will pass across the face of the Sun in its highly anticipated, June 8 transit.

On May 5, Venus reaches its northernmost point in Earth's sky, greater than at any time in the 20th century. This means it sets in the northwest really late, toward midnight.

Mars continues its valiant but doomed escape from the advancing twilight. It appears to slide up past Saturn around the 21st, but in reality both planets are losing ground, with Saturn slumping faster. Saturn remains a glorious telescopic sight despite the deleterious effects wrought by looking through thick layers of Earth's atmosphere. In contrast, Mars shows a tiny, fuzzy disk with no redeeming qualities; only its motion across the sky is truly worth following. Mars's orange glow pales in comparison to Saturn's steady yellow light.

Be sure to save some quality time for observing Jupiter. The king of planets always presents a fascinating face. At first glance, two purplish-brown belts seem to dominate the disk. As you gain experience, details start blossoming into view. To the patient observer, temperate belts and zones farther from the equator spring forth, adorned with all sorts of ripples and irregularities.

A total lunar eclipse occurs on May 4. The Moon's bright, full face slides into Earth's dark umbral shadow, turning a coppery sheen for observers in the Eastern Hemisphere. The Moon rises during totality for Ireland, Scotland, and South America, but it has exited the shadow by the time it rises over North America. No worries — they'll have a grand view of a total lunar eclipse on October 27/28.

The Moon returns to the evening sky as a slender crescent below Venus on May 20, then it climbs between Venus and the Mars–Saturn pair on the 21st. Watch how the triangle formed by the Moon, Mars, and Saturn changes shape in just a few hours on the 22nd.

While this observing season can't compare with the Crab supernova of 1054, rest assured you'll be talking about the celestial wonders of spring 2004 for years to come.

NEW Celestron StarBright XLT High Performance Optical Coatings Outperform The Competitor's UHTC.

StarBright XLT — An Optical System Breakthrough! Celestron has taken its renowned StarBright technology to *an even higher level of light transmission* with the introduction of our new **optional** StarBright XLT High Performance Optical Coating System.

StarBright XLT Optical System Design — You'll See The Light.

One of the most important factors in the evaluation of a Schmidt-Cassegrain telescope's optical system performance is its transmission — the percentage of incoming light that reaches the focal plane. The design of the XLT System accomplishes two crucial objectives: Develop a coating system that is optimized for visual use *and* for CCD/Photographic imaging.

Celestron StarBright XLT: The Bottom Line.

- **11% brighter than UHTC across the spectrum from 400nm to 750nm.** (See Fig.#1)
- **11% more photons will be detected with a CCD camera using StarBright XLT coating system compared to UHTC coatings** (See Fig.#2)
- **6% brighter than UHTC to the dark-adapted eye** (See Fig.#3)
- **16% brighter than our standard StarBright coating across the spectrum from 400nm to 750nm.**

System Transmission At Specific Wavelengths — Celestron StarBright XLT vs UHTC

	Wavelength (nm)	StarBright XLT	UHTC Measured	Percent Improvement
H-beta	486	87.5	83.0	**5%**
Helium II and O_3	496	88.0	84.0	**5%**
O_3	501	88.0	84.3	**5%**
Center of dark adapted vision	510	88.7	84.8	**5%**
Helium I	588	88.0	81.6	**8%**
N_2	655	84.0	73.8	**14%**
N_2 and H-alpha	658	84.0	73.0	**15%**
Sulfur II	673	83.0	72.0	**15%**

System Transmission for StarBright XLT and UHTC

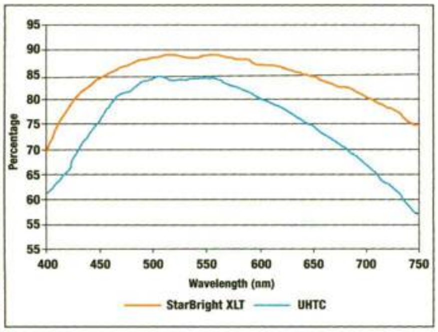


*__Fig #1:__ This is a plot of measured system transmission for Celestron's StarBright XLT and UHTC coatings. The StarBright XLT coating has an overall average system transmission of 83.5% compared to UHTC at 75.1%. System transmission is determined by taking the measured value of the reflectance of the primary, times the reflectance of the secondary, times the transmission of the corrector lens.**

CCD Imaging — It's All In The Photons

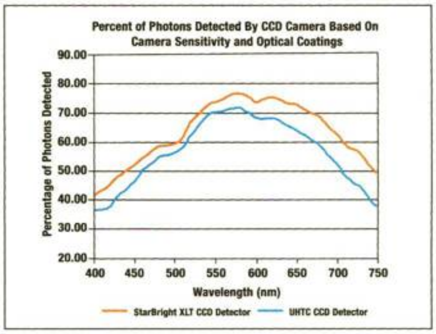


*__Fig #2:__ StarBright XLT is not only optimized for visual use, it is also optimized for imaging. This plot takes into account the sensitivity of a popular CCD chip (KAK-3200 used in SBIG's ST10ME) in conjunction with the system transmission based on the optical coatings. Our measurements indicate that the CCD chip will detect 11% more photons with Celestron's StarBright XLT than UHTC.**

The StarBright XLT System — What makes it different makes it better. — There are three major components that make up our StarBright XLT high transmission optical system design:

1. **Unique enhanced multi-layer mirror coatings** — Our mirror coatings are made from precise layers of aluminum (Al), SiO_2 (quartz), TiO_2 (titanium dioxide), and SiO_2. Reflectivity is fairly flat across the spectrum, optimizing it for both CCD imaging and visual use.
2. **Multi-layer anti-reflective coatings** — Made from precise layers of MgF_2 (magnesium fluoride), and HfO_2 (hafnium oxide). A rare element costing nearly $2000 per kilogram, hafnium gives us a wider band pass than titanium, used in UHTC coatings.
3. **High transmission water white glass** — Celestron Schmidt-Cassegrain optical systems with **optional** StarBright XLT coatings use water white glass instead of soda lime glass for the corrector lens. ***Water white glass transmits about 90.5% without anti-reflective coatings.*** That is 3.5% better transmission than uncoated soda lime glass. ***When water white glass is used in conjunction with StarBright XLT's anti-reflective coatings, the average transmission reaches 97.4% — an 8% improvement!***

For more information about StarBright XLT visit: www.celestron.com/starbrightxlt

Coming Out of the Dark — StarBright XLT Performance Where It Counts

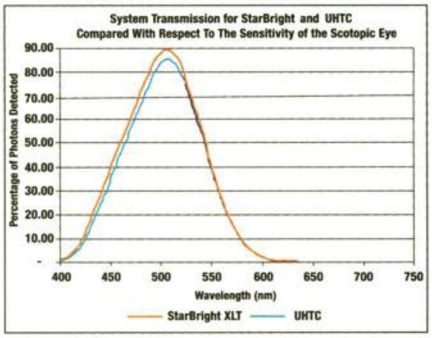


*__Fig #3:__ The scotopic, dark adapted eye is most sensitive at about 510nm. The dark-adapted eye has nearly zero sensitivity below 400nm and above 650nm. This plot compares StarBright XLT and our measurement of UHTC taking into account the sensitivity of the human eye. The result is that StarBright XLT is a __6% improvement over UHTC__ for visual observing .**

UHTC Coatings Don't Measure Up To StarBright XLT

In order to determine how our newly designed XLT performs compared to the competition, we tested several optical systems with UHTC coatings. All measurements have been conducted with spectrophotometers measuring light transmission of coated correctors and reflectance of coated mirrors. This allows us to compare the transmission of our correctors and the reflectance of our mirrors against those of the competition. To ensure the integrity, accuracy, and reliability of these test results, they have been independently verified. A detailed description of our testing process can be found on our website: **www.celestron.com/starbrightxlt**.*

****Percent differences are calculated by taking the comparison data percentage divided by the baseline data. Example: Measured average system transmission for UHTC is 75.1%. XLT average system transmission is 83.5%. 83.5% divided by 75.1% = 1.11 or 11% improvement. Measurement results are rounded to the nearest whole percentage.***

StarBright XLT Pricing

All 8" Schmidt-Cassegrain Products	$125
All 9.25" Schmidt-Cassegrain Products	$175
All 11" Schmidt-Cassegrain Products	$225
All 14" Schmidt-Cassegrain Products	$275

NEW 2003 PRODUCT GUIDE

To request a copy of Celestron's new 2003 Product Guide, contact us at (310) 328-9560.

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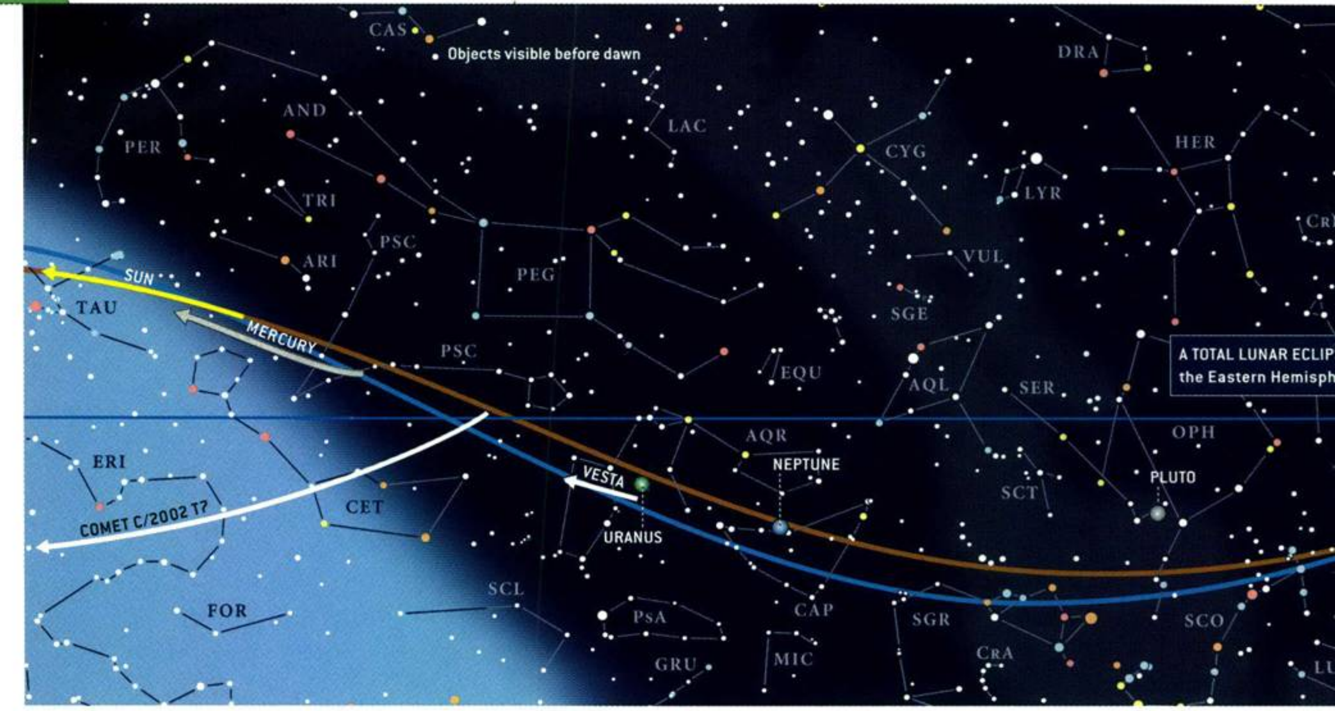
StarBright XLT is a trademark of Celestron.

Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and c


CAS
Objects visible before dawn
DRA
AND
LAC
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LYR
CR
PSC
ARI
VUL
SUN
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TAU
SGE
MERCURY
PSC
EQU
AQL
SER
A TOTAL LUNAR ECLIP
the Eastern Hemisph
AQR
OPH
ERI
VESTA
NEPTUNE
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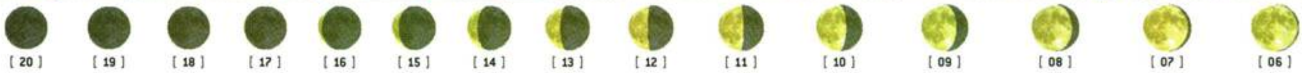
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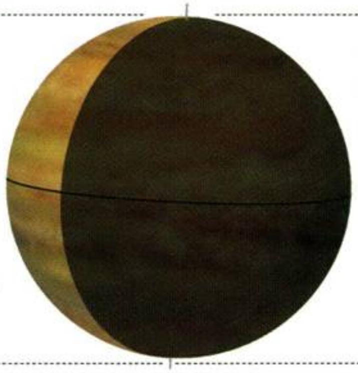
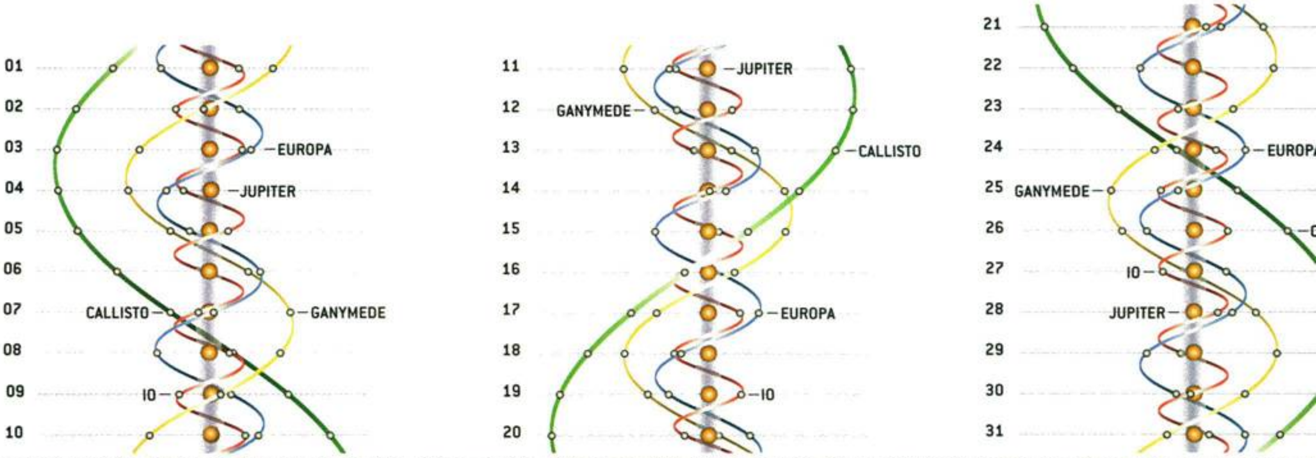
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to t



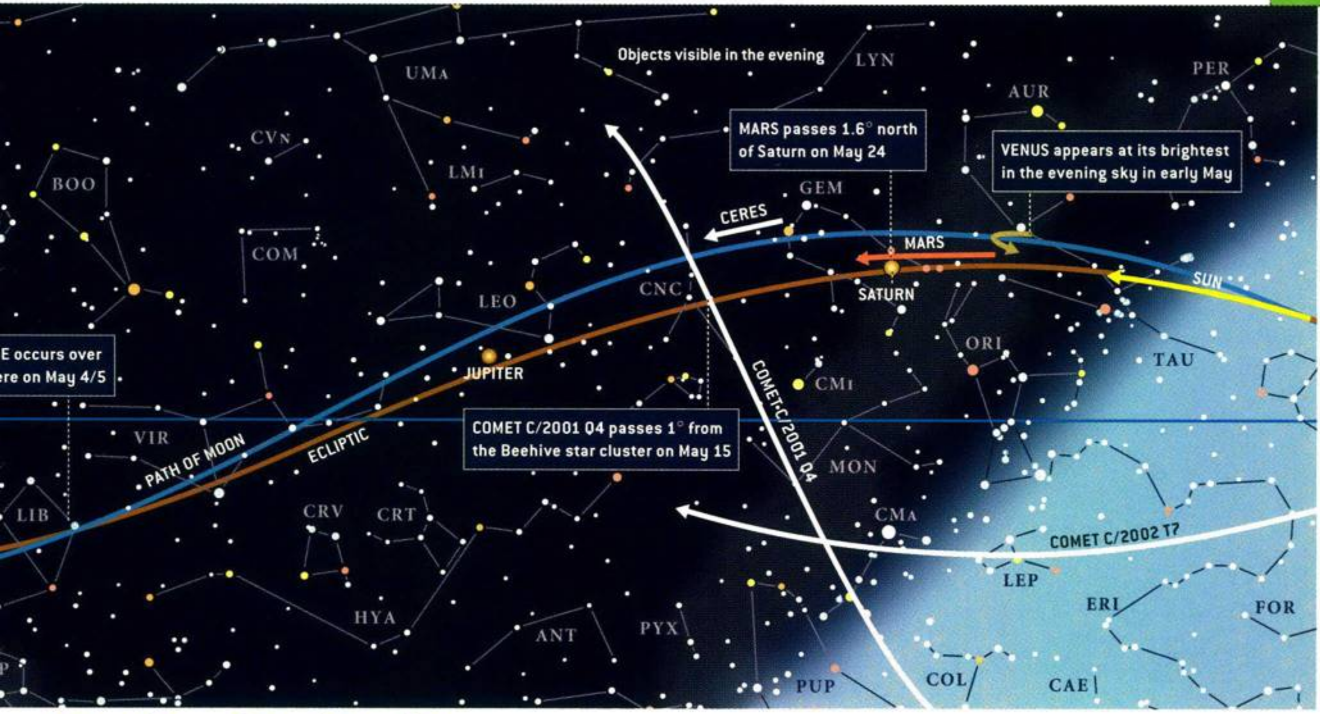
PLANETS	MERCURY	MERCURY	VENUS	VEN
Date	May 1	May 31	May 1	May
Magnitude	1.8	−0.4	−4.5	−4.
Angular Size	10.6"	6.1"	36.1"	45.
Illumination	16%	70%	29%	16%
Distance (AU) from Earth	0.633	1.104	0.462	0.3
Distance (AU) from Sun	0.465	0.376	0.721	0.7
Right Ascension (2000.0)	1h20.6m	3h12.9m	5h20.1m	5h4
Declination (2000.0)	6°35′	15°41′	27°44′	27°

Jupiter's moons

Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.



olored dots show motions and locations of solar system objects during the month.


LYN
PER
AUR
UMA
CVN
LMI
BOO
GEM
CERES
COM
MARS
SUN
SATURN
LEO
CNC
JUPITER
ORI
TAU
CMI
COMET C/2001 Q4
VIR
PATH OF MOON
ECLIPTIC
MON
LIB
CRV
CRT
CMA
COMET C/2002 T7
LEP
HYA
ANT
PYX
ERI
FOR
P
PUP
COL
CAE

Objects visible in the evening

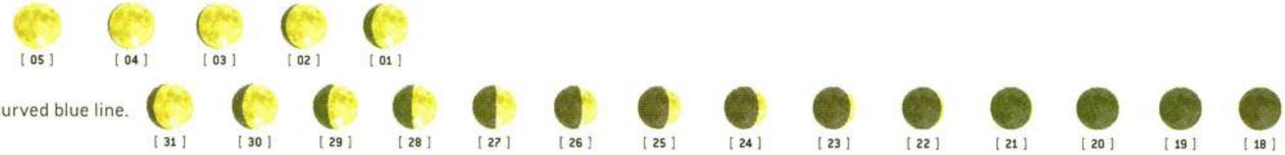
MARS passes 1.6° north of Saturn on May 24

VENUS appears at its brightest in the evening sky in early May

E occurs over
ere on May 4/5

COMET C/2001 Q4 passes 1° from the Beehive star cluster on May 15

he curved blue line.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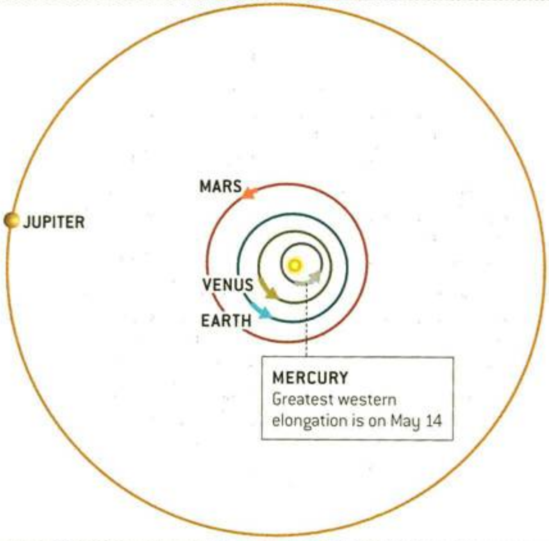
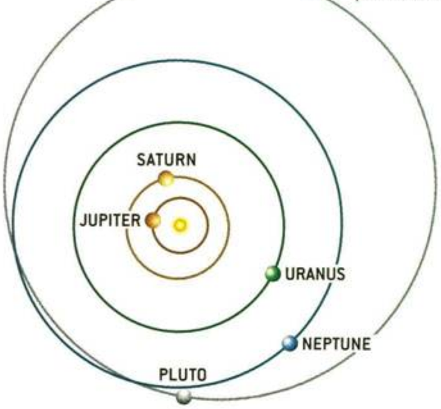
US	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
15	May 15	May 15	May 15	May 15	May 15	May 15
	1.7	−2.1	0.1	5.9	7.9	13.8
	4.1"	38.8"	17.1"	3.5"	2.3"	0.1"
	96%	99%	100%	100%	100%	100%
0	2.264	5.087	9.716	20.232	29.895	29.902
3	1.631	5.430	9.039	20.046	30.072	30.794
.7m	6h21.0m	10h44.4m	6h44.0m	22h34.0m	21h11.2m	17h25.5m
6'	24°36'	9°24'	22°42'	−9°51'	−16°17'	−14°15'


JUPITER
MARS
VENUS
EARTH

MERCURY
Greatest western elongation is on May 14

The planets in their orbits

Arrows and dots show planets' positions during the month.


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

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StarBright® XLT
HIGH PERFORMANCE OPTICAL SYSTEM

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NexStar 8 GPS w/StarBright XLT	$ 2324
NexStar 9.25 GPS	$ 2799
NexStar 9.25 GPS w/StarBright XLT	$ 3019
NexStar 11 GPS	$ 3224
NexStar 11 GPS w/StarBright XLT	$ 3504

For more information, visit: www.celestron.com/starbrightxlt

NexStar® GPS.
Love At First Sight.

Celestron's renown NexStar GPS computerized Schmidt-Cassegrain telescopes continue to draw admiration and praise for their **unsurpassed optical quality**, **state-of-the-art design and engineering**, and **ease of use**. ***With fork mounts, drive bases and optical systems manufactured in our U.S.A. facility***, Celestron's NexStar GPS series continues to set the standard for features and performance *again* with the optional StarBright XLT High Performance Optical System, and our newest innovation: ***NexRemote***. NexRemote puts all of the functions and features of our NexStar hand control onto your PC or laptop. With NexRemote, you can remotely set up and control your NexStar GPS, and it's **compatible with most hand-held GPS units**. It can be used with popular planetarium software programs. You can create multiple custom tours. ***An audible voice describes celestial objects as they are selected from the hand controller, and you can even use a hand-held wireless controller to operate your telescope!*** These are just a few of NexRemote's great features. Best of all, it's ***FREE*** with all NexStar GPS models.

NexStar GPS Quality Features At A Glance

Here are just a few of the design and engineering features that have earned the NexStar GPS series worldwide admiration and respect:

Quality Components

- Pittman Lo-Cog® brush commutated DC motors; made in U.S.A.
- 32-pitch, 5.625" pitch diameter, 180-tooth Bronze gear
- Stainless steel worm shaft
- Precision annealed Pyrex® primary and secondary mirrors
- **Carbon Fiber Tube** –1/4 the thermal expansion of aluminum

Intelligent Design

- Built-in GPS receiver, magnetic compass and internal altitude switch
- Internal Slip Ring to eliminate power cables from wrapping
- Auxiliary ports located on the rotating base
- Ergonomic design for easy transport
- Optical Tube Assembly Mounting Rails
- Unique roller bearing and shaft design creates an effectve 10" diameter Azimuth bearing for maximum stability

Software

- 40,000+ object database; GPS Align; Quick Align; Magnetic North Compass Compensation; Hibernate; EQ Auto Align; Polar Alignment Routine; User-defined filter limits; User-defined slew limits

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NexStar 11 GPS ▸

NexStar 9.25 GPS**

NexStar 8 GPS

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**NexStar 9.25 GPS shown with these optional accessories: Equatorial Wedge (#93655), Radial Guider (94176), and MicroGuide Reticle Eyepiece (#94171). Camera not included.
***120V AC Adapter included for U.S.A. and Canada only.

	NexStar 8 GPS Model 11052	NexStar 9.25 GPS Model 11056	NexStar 11 GPS Model 11053
Eyepiece	1.25" 40mm Plössl (51x)	1.25" 40mm Plössl (59x)	1.25" 40mm Plössl (70x)
Finderscope	9x50	9x50	9x50
AC Adapter***	Included	Included	Included
Tripod	Heavy-Duty Adjustable	Heavy-Duty Adjustable	Heavy-Duty Adjustable
Fastar Compatible	Yes	No	No
Mirror Coatings	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer	StarBright®, 5-step multi-layer
Telescope Weight	42 lbs	58 lbs	65 lbs.
Price*	**$2169**	**$2799**	**$3224**
StarBright XLT*	**$2324**	**$3019**	**$3504**
Shipping & Handling	$95	$115	$125

To design the perfect telescope family for the beginner or advanced user, you have to think BIG.

C6-RGT
[#11046]

C8-S/C8-SGT/C9¼-S/C9¼-SGT
NOW AVAILABLE WITH OPTIONAL

StarBright XLT
HIGH PERFORMANCE OPTICAL SYSTEM

8" Advanced Series Schmidt-Cassegrain Products.......$125

9¼" Advanced Series Schmidt Cassegrain Products...............$175

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www.celestron.com/starbrightxlt

The new Advanced Series and Advanced Series **Computerized GoTo** telescopes have been designed to offer the novice or more advanced user a selection of models with the **features, quality** and **value** that serious amateurs can appreciate. These scopes come on **NEW heavy-duty German Equatorial mounts** with **NEW ultra-sturdy 2" stainless steel legs** and center brace and accessory tray for superior stability, rigidity and vibration dampening. The Advanced Series comes in a choice of refractor, reflector and Schmidt- Cassegrain models. The refractor models range from a 4" to an impressive 6" aperture. For even more light gathering power there are 6", 8" and a **NEW 10" Newtonian** reflector. There are also 5", 8" and 9 1/4" Schmidt-Cassegrain optical designs that feature Celestron's **precision matched and hand-figured optical systems.**

Auxiliary ports for Hand Control, Dec Motor and AutoGuider.

CG-5 Mount — Precision engineered for stability.

Our **new CG-5 German Equatorial Mount** has precision worm gears on both axes for extremely smooth tracking and slewing. The CG-5 uses large shaft and bearings and substantial base castings for additional stability. The key element that makes this system the most stable in its class is the **NEW heavy-duty tripod** with **larger and more substantial legs** that provide excellent damping characteristics for more stable views. The CG-5 also has a convenient **latitude scale** for easier alignment and an **optional polar finder scope** for the ultimate in precision alignments.

Additional Specifications — Computerized Models

Hand Control	Double line, 16 character Crystal Display; 19 fiber optic backlit LED buttons
Motor: Type	DC Servo motors with encoders, both axes
Max Slew Speed	4°/second
Software Precision	24bit, 0.08 arcsec calculation
Hand Control Ports	RS-232 communication port on hand control
Motor Ports	Aux Port, Autoguide Ports
Tracking Rates	Sidereal, Solar and Lunar
Tracking Modes	EQ North & EQ South
Alignment Procedures	AutoAlign, 2-Star Alignment, Quick Align
Database	40,000+ objects, 400 user defined programmable objects

GoTo convenience and GPS compatibility for precision accuracy.

C9¼-SGT
[#11046]

We are proud to offer the GT versions of the Advanced Series on a computerized **GoTo** version of Celestron's sturdy CG-5 mount. Couple this solid mount with the included **NexStar® computer control system** and utilize many of the same features as Celestron's most advanced GoTo telescopes like an **Autoguider port** for long exposure deep sky astro-photography. **GoTo models are also upgradeable to GPS** with the optional **CN16 GPS Accessory (#93963).** It allows your telescope to pinpoint your position on the Earth, the date and time, and makes the alignment process faster and easier than ever before!

C10-NGT
[#11048]

These GoTo versions of the Advanced Series also come loaded with new software features and **over 40,000 database objects**. Capable of holding over 35 lbs of payload and slewing at 4° per second, you will be able to instantly point to any of the celestial objects in the database.

Specifications — All Advanced Series Telescopes

	21016 C4-R	11071/11072 C5-S	31056 C6-N	21019/21020 C6-R	11025/11024 C8-S	31061/31062 C8-N	11045/11046 C9 1/4-S	11047/11048 C10-N
Optical Design	102mm (4.0") refractor	127mm(5") Schmidt-Cassegrain	150mm (6.0") reflector	150mm (6.0") refractor	203mm (8") Schmidt-Cassegrain	200mm (8.0") reflector	235mm (9.25") Schmidt-Cassegrain	254mm (10") reflector
Focal Length	1000mm f/10	1250mm f/10	750mm f/5	1200mm f/8	2032mm f/10	1000mm f/5	2350mm f/10	1200mm f/4.7
Finderscope	6x30	6x30	6x30	9x50	6x30	9x50	6x30	9x50
Mount	CG-4 Equatorial	CG-5 Equatorial	CG-4 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial	CG-5 Equatorial
Eyepiece	1-1/4" – 20mm (50x)	1-1/4" – 25mm (50x)	1-1/4" – 20mm (38x)	1-1/4" – 20mm (60x)	1-1/4" – 25mm (81x)	1-1/4" – 20mm (50x)	1-1/4" – 25mm (94x)	1-1/4" – 20mm (60x)
Star Diagonal	1-1/4"	1-1/4"	n/a	1-1/4"	1-1/4"	n/a	1-1/4"	n/a
Accessory tray	yes	yes	yes	yes	yes	yes	yes	yes
Tripod	Aluminum	2" Stainless Steel	Aluminum	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel	2" Stainless Steel
CD ROM	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky Level 1	The Sky L1

NEW 2003 PRODUCT GUIDE

To request a copy of our new 2003 Product Guide, contact us at (310) 328-9560.

PRICING*: C10-NGT (#11048): $1,149 + $95 S&H; C10-N (#11047):$849 + $75 S&H; C9¼-SGT (#11046): $1,699 + $105 S&H; C9¼-S (#11045): $1,399 + $85 S&H; C8-SGT (#11026): $1,299 + $75 S&H; C8-S (#11025): $999 + $85 S&H; C8-NGT (#31062): $949 + $85 S&H; C8-N (#31061): $649 + $65 S&H; C6-RGT (#21020): $999 + $95 S&H; C6-R (#21019): $799 + $75 S&H; C6-N (#31056) $399 +$50 S&H; C5-SGT (#11072): $1,099 + $75 S&H; C5-S (#11071): $849 + $65 S&H; C4-R (#21016): $399 + $40 S&H

*Prices shown are U.S. mail order.

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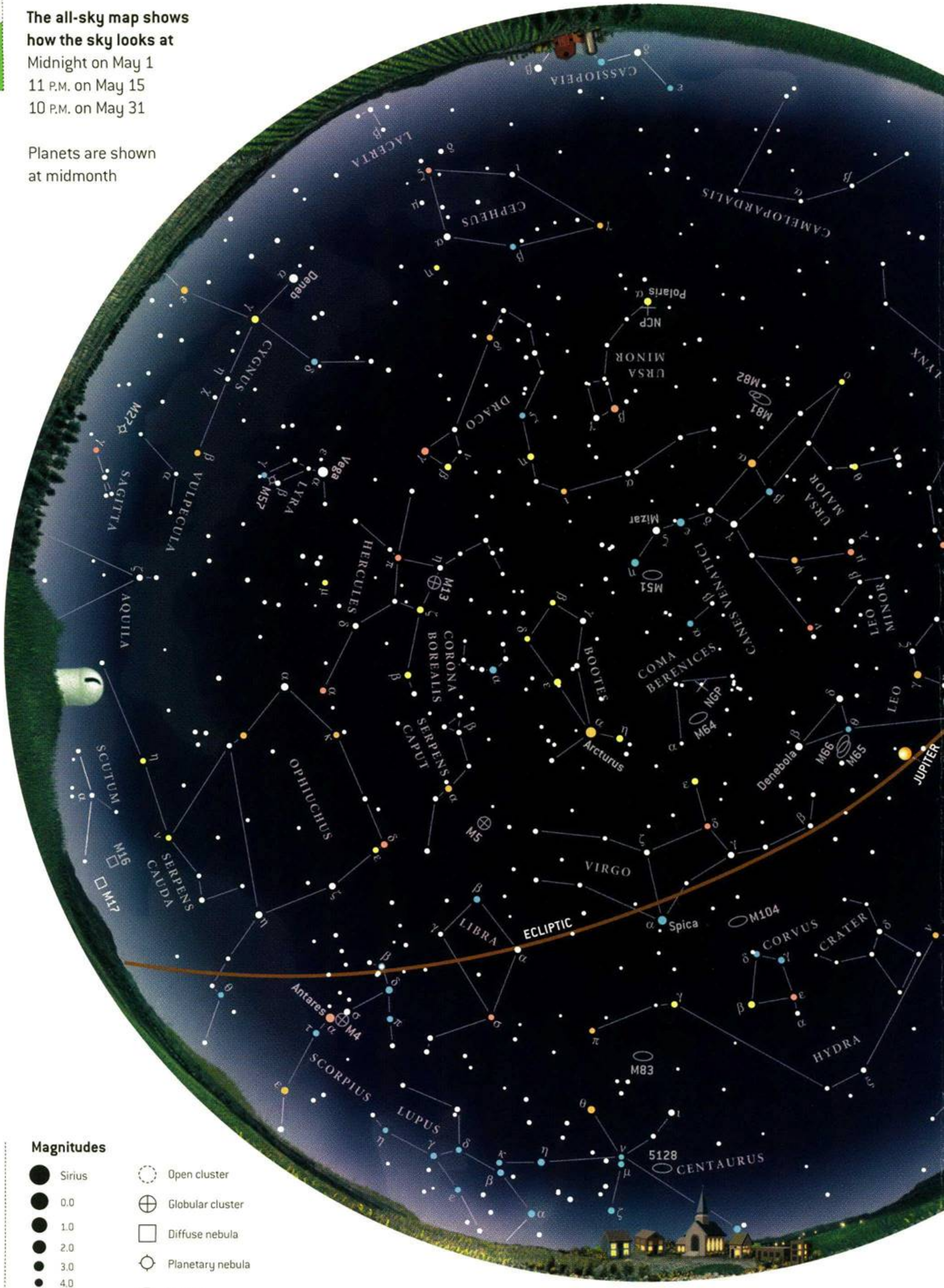
The all-sky map shows how the sky looks at
Midnight on May 1
11 P.M. on May 15
10 P.M. on May 31

Planets are shown
at midmonth

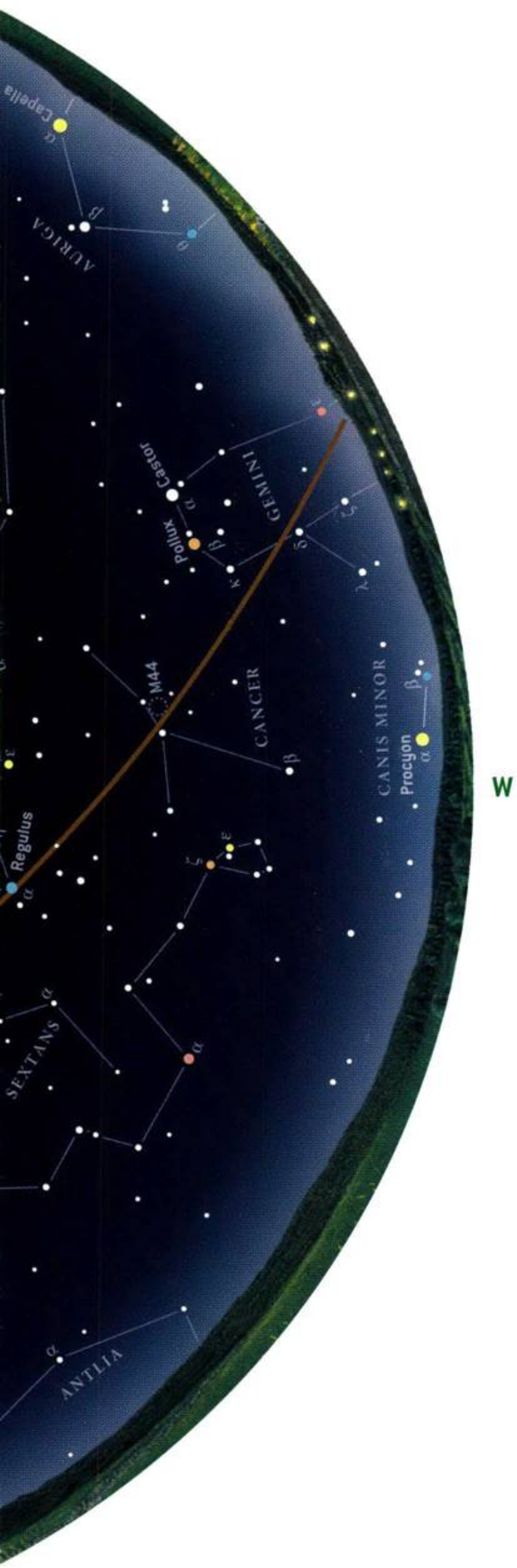

N
E
S
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
LYNX
Deneb
Polaris
NCP
URSA MINOR
CYGNUS
DRACO
M82
M81
M27
SAGITTA
VULPECULA
Vega
LYRA
M57
URSA MAJOR
Mizar
HERCULES
M13
M51
CANES VENATICI
LEO MINOR
AQUILA
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
LEO
M64
SERPENS CAPUT
Arcturus
OPHIUCHUS
SCUTUM
Denebola
M66
M65
JUPITER
M5
M16
M17
SERPENS CAUDA
VIRGO
LIBRA
ECLIPTIC
Spica
M104
CORVUS
CRATER
Antares
M4
SCORPIUS
M83
HYDRA
LUPUS
5128
CENTAURUS

Magnitudes

● Sirius
● 0.0
● 1.0
● 2.0
● 3.0
● 4.0
• 5.0

Open cluster
⊕ Globular cluster
☐ Diffuse nebula
Planetary nebula
⬭ Galaxy

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: no
horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


Capella
α
AURIGA
β
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Castor
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GEMINI
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M44
CANCER
β
CANIS MINOR
Procyon
α
β
Regulus
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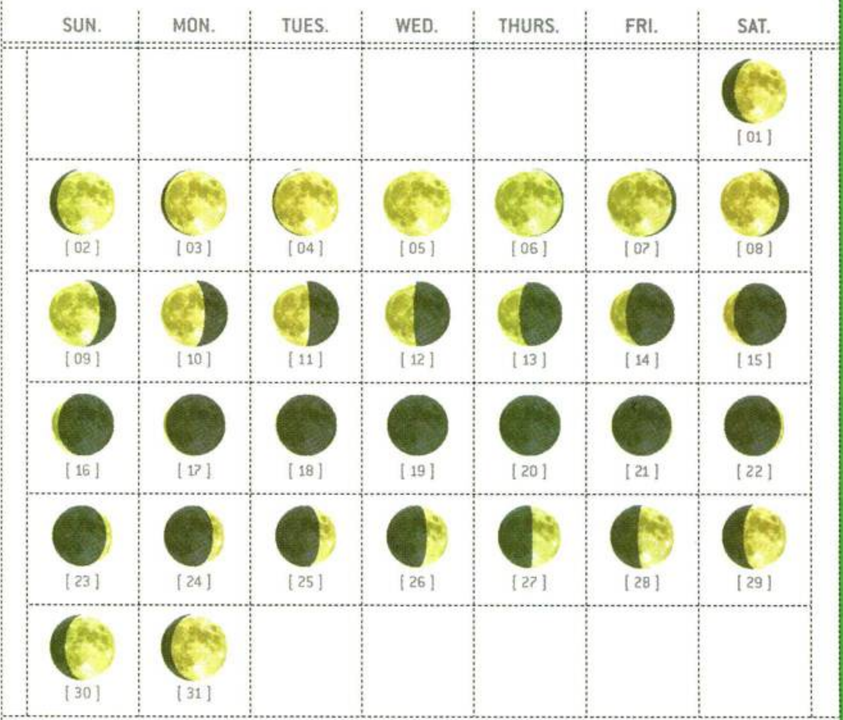
SEXTANS
α
ANTLIA
α
W

rth, south, east, and west. To find stars above your

may 04



SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
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[23]	[24]	[25]	[26]	[27]	[28]	[29]
[30]	[31]					

02 Venus is at greatest brilliancy (magnitude –4.5), 4 A.M. EDT

04 Full Moon is at 4:33 P.M. EDT; total lunar eclipse

Eta Aquarid meteor shower peaks

05 Jupiter is stationary, 9 A.M. EDT

06 The Moon is at perigee (223,576 miles from Earth), 12:32 A.M. EDT

10 The Moon passes 5° south of Neptune, 6 P.M. EDT

11 Last Quarter Moon is at 7:04 A.M. EDT

12 The Moon passes 4° south of Uranus, 8 A.M. EDT

14 Mercury is at greatest western elongation (26°), 5 P.M. EDT

16 The Moon passes 3° north of Mercury, 7 P.M. EDT

19 New Moon is at 12:52 A.M. EDT

21 The Moon is at apogee (252,441 miles from Earth), 8:00 A.M. EDT

The Moon passes 0.3° north of Venus, 8 A.M. EDT

22 The Moon passes 3° north of Mars, noon EDT

The Moon passes 5° north of Saturn, 2 P.M. EDT

24 Mars passes 1.6° north of Saturn, 7 P.M. EDT

27 First Quarter Moon is at 3:57 A.M. EDT

The Moon passes 4° north of Jupiter, 8 A.M. EDT

For a definition of terms, visit www.astronomy.com/glossary

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OMNI® Eyepieces — 1 1/4"

- Focal lengths – 4mm, 6mm, 9mm, 12.5mm, 15mm, 20mm, 25mm, 32mm, and 40mm
- **4-element premium symmetrical optical design**
- Fully multi-coated
- 52° (43° for 40mm) Field of View
- 2-step anodize process to prevent reflection from top surfaces
- Blackened lens edges

NEW!

4mm	$ 44.00
6mm	$ 44.00
9mm	$ 44.00
12.5mm	$ 44.00
15mm	$ 44.00
20mm	$ 44.00
25mm	$ 44.00
32mm	$ 54.00
40mm	$ 54.00

NEW!

OMNI® Barlow Lens — 1 1/4"

- 2x
- Fully multi-coated
- Short tube design

1-1/4"OMNI Barlow...........$ 47.00

X-Cel® Eyepieces — 1 1/4"

- **6-element optical design utilizing ED glass**
- Focal lengths – 2.3mm, 5mm, 8mm, 10mm, 12.5mm, 18mm, 21mm, and 25mm
- Fully Multi-coated. All air-to-glass surfaces have 5 layer multi-coating
- Field of view 55°
- Parfocal – little to no focusing adjustments are needed when switching from a low power to high power eyepiece
- 20mm eye relief and soft rubber roll down eyecups
- More than 25mm of clear aperture even on the high powers for comfortable high power viewing
- Each eyepiece comes with a durable plastic case

NEW!

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5mm	$ 69.00	18mm	$ 69.00
8mm	$ 69.00	21mm	$ 69.00
10mm	$ 69.00	25mm	$ 69.00

NEW!

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- Focal lengths – 26mm, 32mm, and 40mm
- 3-element optical design
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- Field of View — 56° (26mm and 32mm), 50° (40mm)
- 22mm Eye Relief

E-Lux® Eyepieces — 1 1/4"

- Focal lengths – 6mm, 10mm, 25mm, and 40mm
- Traditional Plössl optical design
- Fully-coated

2":		**1-1/4":**	
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32mm	$ 69.00	10mm	$ 34.00
40mm	$ 79.00	25mm	$ 34.00
		40mm	$ 34.00

Axiom® Eyepieces — 1 1/4", 2"

- Focal lengths –
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  2": 19mm, 34mm, 40mm, and 50mm
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- Fully multi-coated

1-1/4":	
15mm	$139.00
19mm	$149.00
23mm	$179.00
2":	
19mm	$189.00
34mm	$239.00
40mm	$289.00
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10mm	$ 79.00
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10mm Plössl Reticle Eyepiece —1 1/4"...........$124.00

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- Allows you to adapt two eyepieces to the telescope for simultaneous viewing (like binoculars)
- A fantastic 3-D effect when observing many celestial objects

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- Barlow Lens — 2x 1.25"
- Six Colored Eyepiece (Planetary) Filters
- Moon Filter — 1.25"
- Aluminum Carrying Case

Filter & Eyepiece Kit.......$ 149.00

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- **Three-element apochromatic design**
- 27mm clear aperture
- Fully multi-coated

1-1/4"Ultima Barlow.......$ 79.00

Microguide Eyepiece — 1 1/4"

- Laser-etched reticle with a built-in, battery illuminator
- Multicoated 12.5mm Abbe (4-element) Orthoscopic
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Microguide Eyepiece 1-1/4".......$194.00

Collimation Eyepiece

- For precise collimation of Newtonians and helpful for aligning Schmidt-Cassegrains
- Fits into 1-1/4" focusers or diagonals
- Alignment is easy using the small opening on one end and thin cross hairs at the other end
- More accurate than a simple collimation Tool

Collimation Eyepiece.......$ 39.00

Radial Guider

- Use with Schmidt-Cassegrain telescopes in prime focus, deep-sky imaging or astrophotography
- Simultaneously photograph and guide through the optical tube assembly of the telescope
- Adjustable prism and rotating eyepiece collar give wider section of sky for finding a guide star
- Eliminates the problem of differential flexure

Radial Guider.......$124.00

Reducer/Corrector

- Works with all Celestron C5, C8, C9-1/4 , C11 and C14 telescopes
- Minimizes coma and flattens field of view for pinpoint off-axis stars
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- f/6.3 for C5, C8, C91/4 and C11 telescopes and f/7 for the C14 telescope

Reducer/Corrector.......$139.00

2" Mirror Diagonal

- 2" 90° Mirror Diagonal to thread on Schmidt-Cassegrain telescopes
- Includes an adapter to use with refractor telescopes
- Includes an adapter to accept 1 1/4" eyepieces
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- Smooth mechanics that are precision manufactured for reliability

2" Mirror Diagonal.......$ 89.00

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- 7-amp hour
- Two 12V output cigarette lighter ports
- 3V, 6V and 9V outputs for accessories
- Built-in flashlight with red filter cap
- 800,000 candle power halogen emergency spotlight
- Booster terminal on rear side
- Built-in circuit breaker for safety
- Cigarette lighter adapter included
- AC adapter included (120V-220V)

NEW!

Power Tank...........$ 69.00

Vibration Suppression Pads

- Reduces vibration time by almost 100% and decreases vibration amplitude
- The pads fit between the bottom of the tripod legs and the ground

Vibration Suppression Pads (Set of 3)...........$ 59.00

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- Eliminates color aberration inherent in achromatic refractor telescopes
- Eliminates the blue hue around lunar and planetary subjects
- Multi-layer coatings for 95% transmission

NEW!

1-1/4" Contrast - Booster Filter...........$ 49.00

Model A — for 1-1/4" eyepieces

Model B — for backthreads of SC's

LPR (Light Pollution Reduction) Filters

- Made of high quality, flat polished optical glass
- Over 40 layers of coating
- Broadband anti-reflection coating prevents ghosting and improves contrast

LPR Filter — 1-1/4"....$ 69.00
LPR Filter Model B......$ 99.00

1 1/4" Polarizing Filter Set

- Transmits only light moving along a specific plane; increases contrast between surfaces with different planar transmissions
- Polarization effect makes blue skies a deeper blue, eliminates surface reflections and helps reduce atmospheric haze

1-1/4" Polarizing Filter Set......$ 39.00

Eyepiece Filter Sets — 1 1/4"

- An invaluable aid in planetary and lunar observing
- Reduces glare and light scattering
- Increase contrast, definition and resolution
- Lessens eye fatigue

#94119-10 (21, 80A, 15, Polarizing)......$ 44.00
#94119-20 (12, 25, 56, ND-25)......$ 44.00
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#94119-40 (8, ND-13, 47, 82A)......$ 44.00

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- Two red LEDs
- Adjustable brightness
- Uses a single 9V battery (included).

Night Vision

Night Vision Flashlight......$ 19.00

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THE DEEP SKY

Comet C/2001 Q4 (NEAT) serves as a moving guide to many interesting binary stars and galaxies — and one magnificent cluster.

Come together, over me

Watching a bright comet graze a wonderful star cluster is an experience of the highest order, right next to witnessing a total solar eclipse or seeing the grandeur of the Crux–Carina Milky Way for the first time. Facts, figures, and photographs can describe the event, but they can never relay the emotional impact. Years from now, you will be able to remember the sights and sounds from the experience, and the observing companions who were with you, like it happened last night.

Ask anyone who saw the 3rd-magnitude Comet IRAS-Araki-Alcock (C/1983 H1) speed past the Beehive star cluster on May 11, 1983, to recount that night — observing is all about emotional impact; it's why we do it.

A similar opportunity arrives in mid-May, when Comet C/2001 Q4 (NEAT) passes the Beehive. Don't miss this chance — have a back-up plan in case of clouds. Fortunate observers in the Eastern Hemisphere can watch the comet's tail slide in front of the cluster's core on the night of the 15th. Lucky observers in the Americas get two chances to catch the comet floating at the Beehive's side, first on the 14th and again on the 15th.

Grab your binoculars and head to a dark site. This huge cluster, also known as Messier 44, spans 1.6°. The small field of view provided by most telescopes can't do it justice. In any case, the visual impact of having the comet nearby will be the true highlight.

The Beehive has been recognized since the dawn of civilization as a hazy cloud in the heavens. Galileo discovered its true nature as a cluster of stars. Today we know it lies about 550 light-years away from Earth and formed some 700 million years ago.

Doubling up

Comet C/2001 Q4 scoots past the pair of stars Rho^1 (ρ^1) and 53 Cancri on May 18. A 5' canyon separates the 6.0- and 6.2-magnitude components, a gap slightly wider than the outer pair of summer's Double Double in Lyra. Although this may look like a binary star system, 53 Cnc lies far beyond its neighbor. Near Rho^1 lies a true double: Iota (ι) Cancri. The 4th-magnitude primary appears yellow compared with its 6.6-magnitude bluish companion. The pair shows a spacing similar to the colorful double Albireo in Cygnus.

Go the distance

C/2001 Q4 passes 2° east of the dusty spiral galaxy NGC 2683 on May 20. This galaxy is two-thirds as big as the Andromeda Galaxy (M31) and lies ten times farther away. The greater distance drops its brightness to magnitude 9.8, similar to many of the Messier galaxies in Virgo.

Bump up the power with a 10-inch scope and you should see some irregularities at the edge of the galaxy's bright inner zone. Larger apertures will reveal a dust lane similar to Andromeda's.

THE BEEHIVE STAR CLUSTER played host to Comet IRAS-Araki-Alcock on May 11, 1983. The cluster receives a follow-up visit from Comet C/2001 Q4 in the middle of May. ALISTER LING

THE DUSTY SPIRAL GALAXY NGC 2683 in Lynx, a smaller, fainter version of M31 in Andromeda, also greets Comet C/2001 Q4 this month. JACK NEWTON

Martin Ratcliffe *is former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

THE PLANETS

The evening sky remains chock full of planets, but this will be the last month to get good views of most of them.

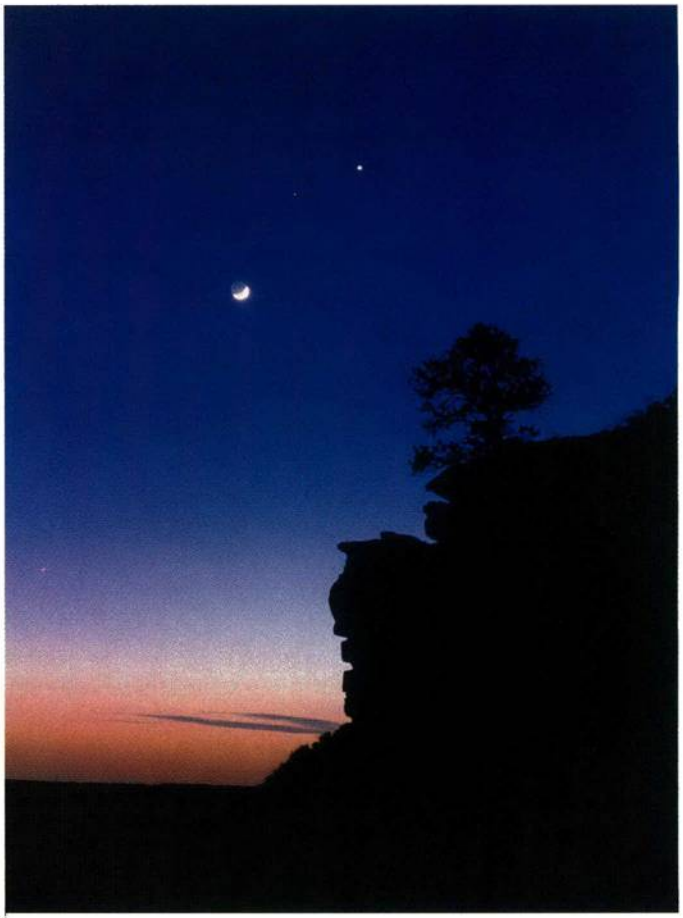
That's Venus dominating the evening sky this month. The brilliant "evening star" stands high in the west in early May. Joining Venus is Mars, which now appears like a bright star above and to the left of Venus. Saturn lies a bit higher up at dusk, among the background stars of Gemini the Twins. Second in brightness only to Venus, Jupiter appears high in the south at sunset, below the midriff of Leo the Lion. Two bright comets also should grace our skies this month, providing stunning exclamation points to the end of a superb planetary season.

Throughout the first several months of 2004, **Venus** climbed higher and higher in the western sky. This motion has now brought it close to Mars and Saturn for a fine planetary grouping. But it won't last long — Venus drops rapidly toward the horizon throughout May and will disappear from view by early June. For North American observers (or anyone around the globe near 40° north latitude), Venus stands 37° above the horizon at sunset on May 1. By mid-May, this value has fallen to 28°, and on the 31st, Venus lies just 9° high at sunset, essentially lost in the brilliant twilight. How late in the month can you still spot it?

On May 1, Venus lies just 1° from El Nath, or Beta (β) Tauri, the star that marks the tip of the upper horn of Taurus the Bull. The planet then shines at magnitude –4.5, its peak brightness during this evening apparition. A telescope shows a 29-percent-illuminated disk that spans 36", approximately one-fiftieth the diameter of the Full Moon.

Venus's telescopic appearance changes dramatically throughout May. The planet's phase shrinks to 16-percent lit on the 15th and just 3-percent lit on the 31st. During the same time, the planet's disk grows to 45" across on the 15th and 56" on the 31st. A quick look at how Venus moves through the solar system helps us understand why this happens. As we view Venus, it lies east (to the left) of the Sun and is moving around its orbit toward us. This brings it closer to Earth, causing the apparent growth, while its lit hemisphere faces more and more away from us. Soon it will pass directly between the Sun and Earth. On June 8, Venus will transit the Sun's face for the first time in 122 years.

A captivating slender crescent Moon lies about 5° below Venus on May 20. The following evening, the waxing lunar crescent sits above Venus.



A CRESCENT MOON JOINS Venus, Mars, and Saturn in the evening twilight between May 20 and 22. The March 19, 1999, conjunction seen here included the same cast, minus Mars. JOHN McNEAL

Moving to a planet beyond Earth's orbit, **Mars** lies 6° to the upper left of Venus on May 1 and crosses from Taurus into Gemini on the 7th. The Red Planet glows at magnitude 1.7, a few hundred times fainter than Venus. Its faintness stems largely from its distance. Mars now lies nearly on the opposite side of the Sun compared with Venus, so the planets' proximity in the sky results solely from a line-of-sight effect.

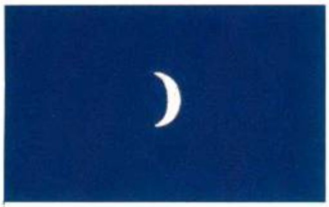
Through a telescope, diminutive Mars appears just 4" across. This tiny size pushes the limit of even large telescopes to show any surface detail. The fascination this month comes from Mars's elegant dance with Saturn.

On May 10, Mars lies midway along the 15° span that separates Venus and Saturn. During the second week of May, Mars chases Saturn across Gemini. On the 12th, the Red Planet passes 2° north of Eta (η) Geminorum. Two days later, Mars lies the same distance north of Mu (μ) Gem and a little more than 5° separate Mars and Saturn. By the evening of May 24, Mars passes 1.6° north of Saturn, their closest point, resulting in a new pair of "stars" centered in Gemini. By the end of the month, Mars has moved 4° above Saturn.

In contrast to Mars, **Saturn** remains a spectacular sight through telescopes this month. The ringed planet shines at magnitude 0.1, easily surpassing Gemini's twin stars, Castor and Pollux. Saturn's disk now spans 17" while the wonderful rings spread 39" across. You should be able to spot the planet's shadow falling on the rings, creating a distinct three-dimensional effect.

Saturn soon will disappear from our evening view. It sets just past midnight on May 1 and around 10:30 P.M. local daylight time as the month rolls into June. But the Cassini spacecraft will keep Saturn in our view throughout summer. Just two months remain before Cassini enters orbit around Saturn, destined to rewrite the textbooks on the planet as well as its rings and moons. Saturn now lies ten times the Sun–Earth distance away from us, so signals from Cassini take approximately 80 minutes to reach us.

Before twilight encroaches late in the month, Saturn's numerous moons will be on display. Titan lies due west of Saturn on May 8 and 24 and due east on May 16. At magnitude 8.3, Titan glows bright enough to be seen in any telescope. Tethys, Dione, and Rhea each shine at 10th magnitude and are seen easily through 6-inch or larger scopes. The two modest moons closest to Saturn, Mimas and Enceladus, shine at magnitudes 13 and 12, respectively. They become more difficult to see as Saturn's low altitude smothers their dim light.

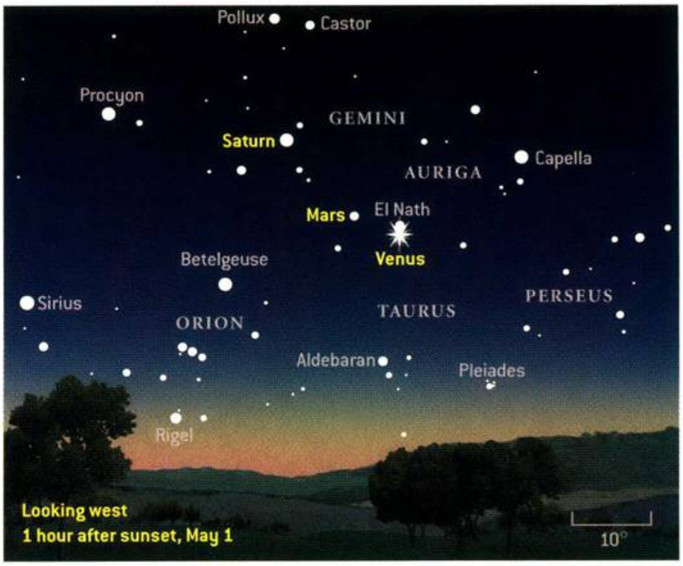


A CRESCENT VENUS will greet observers looking through telescopes this month. The planet's phase shrinks from 29-percent lit on May 1 to just 3-percent lit on the 31st. EDWIN FAUGHN

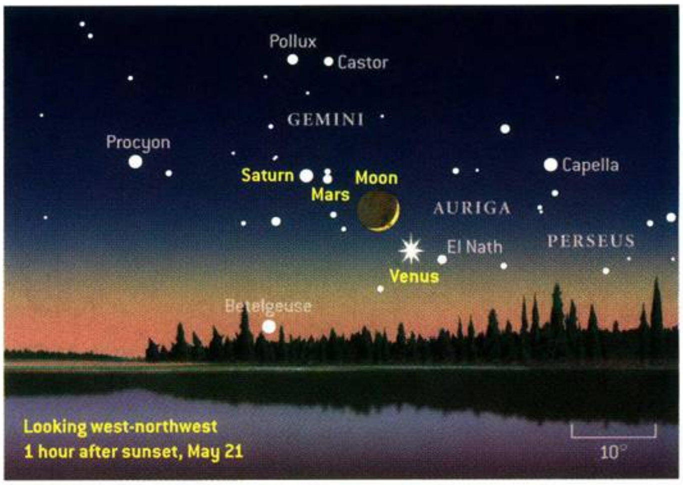
Shortly after sunset, **Jupiter** becomes visible high in the south. Try viewing the planet during twilight, before its brilliance becomes too dazzling. Jupiter shines at magnitude –2.1, making it the second brightest point of light in the sky. A First Quarter Moon lies roughly between Regulus, the brightest star in Leo, and Jupiter on May 26. The following night, Jupiter lies to the right of the Moon.

Jupiter provides enough visual delights to occupy many evenings at the eyepiece. Atmospheric details change hourly and sometimes by the minute. Four bright moons orbit the giant planet, offering a striking view of their continuously changing positions. These motions frequently place the moons in just the right place to drop their shadows onto the face of Jupiter. During their orbits, each moon also passes behind Jupiter and the planet's disk blocks our view.

Jupiter's oval disk stands out in any telescope. It spans 39" across the equator and some 6-percent less through the poles. Jupiter sets well after midnight, offering a giant, planet-sized dose of time to watch various features cross the central meridian (the line that bisects the disk from pole to pole). The Great Red Spot, whose color now appears salmon-pink, transits the disk on the North American night of May 1/2, for example.



Looking west
1 hour after sunset, May 1



Looking west-northwest
1 hour after sunset, May 21

Mercury reaches its greatest elongation (26°) west of the Sun on May 14. It appears low in the morning sky for Northern Hemisphere observers, however. You'll find the planet, perhaps, well to the lower left of the waning crescent Moon that morning. May 16 presents the most favorable time to spot the planet because it lies just 5° to the lower left of the slender crescent Moon then. The planet shines at only magnitude 0.5, so it won't stand out. It brightens later in May but becomes lost in the morning twilight then. Mercury climbs much higher into the predawn sky for Southern Hemisphere observers during this apparition.

METEORS AND MOONS

Although the Full Moon interferes with the month's best meteor shower, a week later, a prominent lunar crater stands out in the giant Imbrium impact basin.

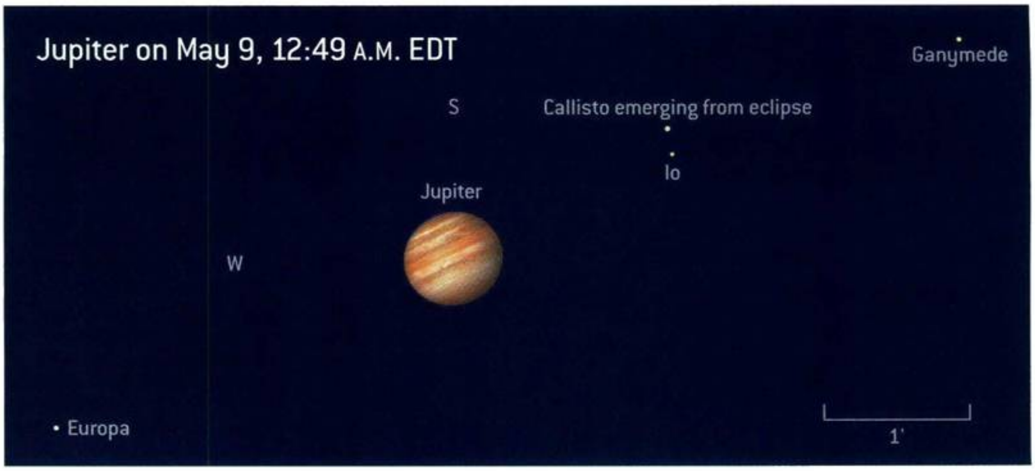
Eta Aquarid meteors

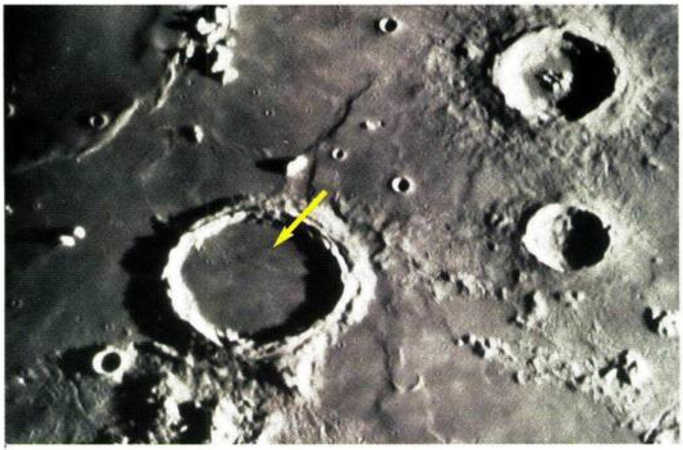
The Moon seriously affects views of this month's Eta Aquarid meteor shower. The shower peaks on May 4 — the same night as the Full Moon. The shower results when Earth crosses the orbit of Comet Halley, running into debris shed by the comet over the millennia. Up to 40 meteors per hour can be recorded under ideal conditions at the peak, but the Full Moon will reduce the number of observable members to a handful.

A Greek icon's crater

Many Moon buffs rate the crater Archimedes among their favorite targets. It lies near the foothills of the spectacular lunar Apennine Mountains, which form the southeastern boundary of Mare Imbrium. Archimedes ranks as the largest crater within Imbrium, the second youngest of the Moon's impact basins.

Archimedes measures 52 miles across and shows a flat, lava-filled floor with no central peak. The terraced walls of the crater rise starkly from the basin floor surrounding it. If the large projectile that created the crater had landed after lava flooded the Imbrium basin, dramatic rays and other signs of youth would be evident. Because the lava covering Mare Imbrium sits neatly around the crater's rising walls, the impact must have occurred between the time Imbrium itself formed and the dramatic flooding.


Jupiter on May 9, 12:49 A.M. EDT


THE CRATER ARCHIMEDES (arrow) — the largest in Mare Imbrium — features a flat floor with no central peak. FROM *THE CONSOLIDATED LUNAR ATLAS* (LPL/UA)

With Full Moon coming on May 4, watch the crater during the second week of May as the Sun's altitude drops over the region. Stark shadows extend across the crater floor as the Sun sets over Archimedes.

Two prominent craters lie near Archimedes: Autolycus lies due east, and Aristillus lies northeast. Aristillus is the larger of the two and has a prominent central peak.

Jupiter's satellites

Occultations, eclipses, and transits involving the outer Galilean moon, Callisto, continue for a few more months. During each 12-year orbit of Jupiter around the Sun, two such series occur; the current one ends in September. The events listed in the table above are given in both Universal Time and Eastern Daylight Time. Tr = transit; I = ingress; E = egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance. The events are worth viewing due to their relative rarity. Not all events are visible from the United States.

/// MAY CALLISTO EVENTS

	{ UT }	{ EDT }	{ Event }
8th	14h10m	10:10	IV.Oc.D.
	17h47m	13:47	IV.Oc.R.
		21:51	IV.Ec.D.*
9th	1h51m		IV.Ec.D.*
	4h49m	0:49	IV.Ec.R.
16th	23h14m	19:14	IV.Tr.I.
		22:50	IV.Tr.E.*
17th	2h50m		IV.Tr.E.*
	11h06m	7:06	IV.Sh.I.
	13h58m	9:58	IV.Sh.E.
25th	7h22m	3:22	IV.Oc.D.
	11h03m	7:03	IV.Oc.R.
	19h57m	15:57	IV.Ec.D.
	22h44m	18:44	IV.Ec.R.

*Events that occur on either side of midnight are shown twice.

COMETS AND ASTEROIDS

Whether you host a neighborhood star party to view the spring comets or play a part in a city-wide comet watch, be prepared for plenty of questions.

Shine on, NEAT

It has finally arrived. Just as Comet C/2001 Q4 (NEAT) hits its peak, it vaults into visibility for Northern Hemisphere observers. Going from being invisible to a fully developed comet, C/2001 Q4 will surely pack a punch.

Plan on observing it every clear night. Nice comets come, on average, once every several years, so make the most of this opportunity. At first, the comet's tail will point generally along the horizon, but it will swing gradually upward from night to night. Avoid city lights because the glow will wash out the beauty of the tail. To get a clearer view, head west or southwest of any nearby city. The farther north you live, the longer you'll have to wait to spy C/2001 Q4. People in Canada and the northern half of Europe won't see the comet until around May 6.

Binoculars or scope?

For the non-astronomer, binoculars deliver the best overall view. Not only can you use both eyes, but you can see the whole comet, with the bright head fading into a magnificent tail. If you don't own binoculars, borrow some. A telescope aimed at the star-bright core might reveal neat features that can change from night to night, but first-time observers have a tough time seeing these details. Binoculars, and even naked-eye views, are typically beyond compare. In short, use both, and encourage as long a look as possible. If you can, have a second scope pointing at Saturn — it never fails to impress newcomers.

Photography ideas

Whether you use a film or digital camera, practice taking pictures before the comet appears so you won't waste time in the dark trying to figure out how the camera takes time exposures. For ISO 400 film at f/2, keep exposures of the comet shorter than 12 seconds to prevent trailing.

Make sure you disable the camera's flash because it will make foreground objects bright and underexpose the comet. You'll probably need to override your camera's automatic settings to force it to shorten the exposure by a factor of two to four; otherwise, it may attempt to turn the image into daytime brightness.

If C/2001 Q4 turns out to be as bright as predicted, you might want to head northeast of your home to get a shot of the comet floating over the distant city skyline in twilight. Some of the best images taken of Comet Hale-Bopp were adorned with foreground color and terrestrial forms. The horizon adds a touch of reality to this other-worldly object.

Tales of sidewalk astronomy

Should you be part of a public event, keep a few things in mind. Most people have never looked through a telescope and typically find observing with one eye awkward. If details can be seen in the comet's core, try using a low-power eyepiece with a Barlow lens to avoid the need for each visitor to refocus. The view through a 4-inch wide-field scope at lowest power inevitably impresses the crowd more than a higher-power view through a large scope. Even better, set up a tripod with binoculars (and a stepping stool for the kids) as part of your optical arsenal. Be ready for questions like "How far away is it?"; "Will it crash into Earth?"; and "What's it made of?"

ONE OF 2004'S BRIGHT COMETS, C/2002 T7 (LINEAR), appeared as a fuzzy blob back on September 26, 2003. MICHAEL JÄGER AND GERALD RHEMANN

Still in the running

For Northern Hemisphere observers, Comet C/2002 T7 (LINEAR) likely will be lost in the fire of NEAT's stardom. On the other hand, if the former fizzles and the latter sizzles, you won't want to miss it. For a few mornings before Full Moon on May 4, C/2002 T7 may capture our hearts and imaginations. Set your alarm for 4:30 A.M. (if you don't stay up all night observing) and scan the horizon due east with binoculars.

After the 4th, C/2002 T7 plunges below the horizon, although observers in the Southern Hemisphere are in for a treat. Around the 27th, the comet returns northward, appearing low in the southwest after sunset, with a nice long tail. Keep an eye out for a "disconnection event," when magnetic lines of force carried on the solar wind cause the gas tail to disconnect. For more on observing both comets, see "A tale of two comets" on page 70. ◼

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Meade LX200GPS-SMT telescopes with Smart Mount Technology have all the performance and features you've dreamed about since you started astronomy – plus you can add optional UHTC (Ultra High Transmission Coatings) for 20% higher light transmission so you can see 20% more of the Universe.

Fully automatic GPS (Global Positioning System) alignment takes the time and guesswork out of setting up your LX200 and aligning it on the heavens. You can start observing in mere minutes.

New and unique Smart Mount Technology can improve your scope's pointing accuracy as you observe. A supplied Lunar Planetary Imager will take digital color pictures for you.

The GPS Autostar computer hand control has a built-in database of over 145,000 stars and objects. It will find any of them for you *automatically.* You'll spend more of your time looking *at* heavenly bodies and less time looking *for* them.

Here are the LX200GPS scopes we ship from our stock:

7" Maksutov-Cassegrain	$\$2695^{00}$
7" Maksutov-Cassegrain, w/UHTC	2845^{00}
8" Schmidt-Cassegrain	2195^{00}
8" Schmidt-Cassegrain, w/UHTC	2370^{00}
10" Schmidt-Cassegrain	2745^{00}
10" Schmidt-Cassegrain, w/UHTC	2980^{00}

Here are the LX200GPS scopes Meade ships from the factory due to their weight:

12" Schmidt-Cassegrain	3595^{00}
12" Schmidt-Cassegrain, w/UHTC	3890^{00}
14" Schmidt-Cassegrain	4695^{00}
14" Schmidt-Cassegrain, w/UHTC	5045^{00}
16" SCT, w/altazimuth pier and UHTC	$15{,}645^{00}$
16" SCT, w/equatorial pier and UHTC	$15{,}845^{00}$

Need an equatorial mount for your optics? We have mounts from $\$399^{\underline{00}}$ to $\$84{,}150^{\underline{00}}$.

Losmandy G-11

Granted, you usually won't find the $84,150 Takahashi computerized mount in stock, but we *do* keep a good inventory of those mounts priced under $10,000.

Here's a partial list of the mounts we had in stock or readily available as this was written:

Celestron CG-5A, wood tripod, no drive	$\$399^{00}$
ASCM, metal tripod, 2-axis go-to	749^{00}
CGE, metal tripod, 2-axis go-to	3000^{00}
Losmandy GM8, metal tripod, 2-axis drive	1449^{00}
GM8GT, metal tripod, Gemini go-to	2449^{00}
GM11, metal tripod, 2-axis drive	2079^{00}
GM11GT, metal tripod, Gemini go-to	3195^{00}
HGM Titan, metal tripod, 2-axis drive	5995^{00}
Meade Starfinder, w/pier, 1-axis drive	1995^{00}
Questar 7" Fork, no tripod, 1-axis drive	$\$6495^{00}$
Software Bisque Paramount ME, no pier or tripod, 2-axis go-to drive	$10{,}000^{00}$
Takahashi P2Z, wood tripod, 1-axis drive	2219^{00}
EM-2S, wood tripod, 1-axis drive	2219^{00}
EM-10, wood tripod, 2-axis drive	2789^{00}
EM-10GT, wood tripod, Temma go-to	3589^{00}
EM-200, wood tripod, 2-axis drive	4449^{00}
EM-200GT, wood tripod, Temma go-to	5299^{00}
NJP/T, wood tripod, 2-axis drive	6049^{00}
NJP/TGT, wood tripod, Temma go-to	6949^{00}
NJP/P, pier, 2-axis drive	6049^{00}
NJP/PGT, pier, Temma go-to	6949^{00}
Vixen GPDX, metal tripod, no drive	1220^{00}
GPDXW, wood tripod, no drive	1400^{00}
GPDXP, pier, no drive	1400^{00}
SPNX/T, metal tripod, Sphinx go-to	2165^{00}

Discovery Dobs are quality-made in the USA.

8" f/6 DHQ
$449

Why settle for an imported Dobsonian with only so-so mass-produced optics when premium made-in-the-USA optical quality costs no more? Discovery's Dobsonian optics are polished to *1/10th wave* surface accuracy by experienced optical craftsmen in California, one high quality mirror at a time. Discovery DHQ Dobsonians have a fast cool-down open back metal mirror cell, a low-diffraction thin vane diagonal spider, *two* 1.25" Plössl eyepieces (25mm and 10mm), a 2" metal rack and pinion focuser with a 1.25" eyepiece adapter, a built-in tube balancing system, tube carry handle, oversized bearings, a 6 x 30mm finder, and a tube end dust cover.

Here are the prices for the fully-equipped made-in-the-USA Discovery DHQ Dobsonians. Freight from the factory in California is additional, as shown.

6" f/8 Discovery DHQ	$\$339^{00}$ + $49 freight
8" f/6 Discovery DHQ	449^{00} + $49 freight
8" f/7 Discovery DHQ	449^{00} + $49 freight
10" f/4.5 Discovery DHQ	649^{00} + $69 freight
10" f/5.6 Discovery DHQ	649^{00} + $69 freight
13.1" f/4.5 Discovery DHQ	999^{00} + $185 freight

Meade go-to . . . *at prices you can afford.*

Meade 5" AR-5 refractor
$695

Why pay for an ordinary telescope when you can get a fully computerized Meade LXD55 for the same price? The go-to LXD55 is the biggest advance in an affordable mount since the German mount was invented in the early 1800s!

You won't spend your time hunting for deep space objects with a 5" or 6" LXD55 refractor or a fast 6", 8", or 10" reflector (with either standard or optional UHTC optics). A few touches on the built-in Autostar computer sends your scope speeding to any of 30,000 stars and objects and tracks it as you observe. You'll spend more of your time looking *at* celestial objects and less time looking *for* them with an LXD55.

Each is complete with adjustable height tripod, dual motor drives, accessory tray, finderscope, eyepiece, and Autostar computer. Order now. Get your German mount observing out of the dark ages.

Meade 8" SN-8 f/4 reflector ($964 w/UHTC)
$839

We actually stock TeleVue. Does your dealer?

NP-101 **$3595**

To sell seven figures worth of TeleVue a year, you have to keep a lot of it in stock so you can ship fast and keep your customers happy. We *do* keep a big inventory on hand, so our customers are *very* happy. Others may say they carry TeleVue, *but we actually keep TeleVue in stock.* Lots of it.

Here are a few of the TeleVue refractors that we keep in stock for immediate shipment.

Pronto, 2.7" f/6.8 semi-apo	$\$1120^{00}$
TV-76, 3" f/6.3 apo	1675^{00}
TV-85, 3.35" f/7 apo	2080^{00}
TV-102, 4" f/8.6 apo	2635^{00}
Renaissance 102, 4" f/8.6 brass apo	3175^{00}
NP-101, 4" f/5.4 apo	3595^{00}

All of the above refractors come without a mount, but include an eyepiece (except the NP-101), an enhanced aluminum or 99% reflectivity Everbrite star diagonal, a carrying case, and a tube ring for mounting. Optical tubes only, without these accessories (such as the new **TV-60** apochromatic at $795), are also available from stock.

As for accessories, we stock them all. For example, here are a few of the newest eyepieces from TeleVue that we can ship today.

2-4mm 1.25" Nagler zoom	$\$395^{00}$
2.5mm 1.25" Nagler Type 6	280^{00}
3.5mm 1.25" Nagler Type 6	280^{00}
11mm 1.25" Nagler Type 6	280^{00}
20mm 2" Nagler Type 5	440^{00}
41mm 2" Panoptic	495^{00}

Whether it's a Gibraltar, Panoramic, or Tele-Pod mount; a Sky Tour computer; a Nagler, Radian, Panoptic, or Plössl eyepiece; a Powermate or Barlow; an Everbrite 99% reflectivity star diagonal; a light pollution filter, or a BinoVue – if it's TeleVue, it's in stock.

Why wait for another dealer to *order* your scope? We'll ship your Meade LX90 from our stock . . .

$1695
Meade 8"

The **Meade LX90** lets you enjoy go-to astronomy for not a lot of money. The 8" LX90 with standard optical coatings is only $1695. UHTC (Ultra High Transmission Coatings) optics give you up to 20% brighter images for only $175 additional. The LX90 has a heavy-duty adjustable height tripod, 26mm Super Plössl eyepiece, Autostar computer with 30,223 star and object memory, 8 x 50mm finder.

There's no need to wait for another dealer to order an LX90 for you to enjoy. We usually have the LX90 in stock at all times (over twenty, both standard and UHTC versions, were in our inventory as this was written), so you can probably get *your* LX90 with little or no delay.

Right angle finders at new lower prices.

We stock **Antares** 8 x 50mm and 12 x 80mm right angle finders at new lower prices from $79⁹⁵ to $239⁹⁵. Choose from Celestron black, Meade blue, or a gloss white in either standard mirror-image versions or erect right-reading models that show you the sky the way it appears on star charts. Each is available with either dark crosshairs or a unique built-in cordless red disk illuminator. Economical optional quick release mounting brackets are also available.

Antares 12 x 80mm
$174⁹⁵

Are these the best Schmidt-Cassegrain optics?

Celestron NexStar 9¼ GPS
$2799

Many observers think that the **NexStar 9¼ GPS** has the sharpest and highest contrast optics that Celestron has ever made. In addition to extraordinary 9.25" f/10 optics, you get all of the features you expect from a GPS scope plus some unique features that are unavailable in other scopes.

For example, its optical tube is carbon fiber – *not* ordinary aluminum. Carbon fiber's lower coefficient of thermal expansion means you'll never worry about temperature-induced focus changes during photography or high magnification planetary observing. In addition, you get the brighter images of Starbright high transmission multicoated optics *at no extra cost!* You can even add optional state-of-the-art Starbright *XLT* coatings for Celestron's brightest images ever. The best SCT optics? They're only one of the many reasons to buy a NexStar 9¼ GPS.

astronomics

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We'll sell you the *right* telescope.

This month's hot products . . .
new lower-priced SBIG ST-7XME CCD cameras!

SBIG has reduced the price of their ST-7XME self-guiding CCD camera, and added new versions for as little as $1495! The ST-7XME Standard is now only $1995. It includes a Class 2 imaging detector with no column defects, large TC-237H guiding detector, custom case, high speed USB interface, thermoelectric cooling with whisper fan, and more.

The new ST-7XME Deluxe upgrades the standard model to a Class 1 detector, and adds CCDSoft version 5 image processing software and other accessories. At only $2495, it's $200 less than the cost of the original ST-7XME.

The ST-7XMEI drops the guiding detector and some accessories from the Standard camera (you can add them later if you need them), to give you a premium CCD imaging camera, without built-in self-guiding, for only $1495!

Denkmeier Binoviewers are optimized for *your* scope.

Use both eyes to observe through a **Denkmeier Binoviewer**, and you can see up to 40% more detail than you can when looking through a single eyepiece. Your views of the planets, Moon, and deep space objects become almost three-dimensional. Whether you have a refractor, reflector, or a Schmidt-Cassegrain, there is a Denkmeier Binoviewer with specialized optics that are optimized to give you peak visual performance with your scope's particular optical design. Prices start at $599.

Sell your used telescopes and accessories quickly *for free* by using the no-charge classified ads at www.astrofieds.com

Our *38* light pollution filters make bright skies dark.

If city lights wash out your view of the skies, get rid of the pollution with one of the 38 different light pollution reduction filters we stock.

We have two **Celestron** broadband filters. One is designed for 1.25" eyepieces; one for Schmidt-Cassegrain (SCT) rear cells.

We have 13 **Lumicon** Deep Sky broadband, UHC narrowband, and H-Beta and Oxygen III line band filters for use in 1.25" and 2" eyepieces, as well as on SCT rear cells.

We have six **Meade** broadband, narrowband, and Oxygen III filters in 1.25" eyepiece and SCT rear cell versions.

We have four **Sirius** contrast enhancement and nebula filters for 1.25" and 2" eyepieces, plus a unique 1.25" *variable* nebula filter.

We have four **TeleVue** Bandmate NebuStar UHC-type narrowband and Oxygen III filters in both 1.25" and 2" eyepiece versions.

We have eight **Thousand Oaks** broadband, narrowband, Oxygen III, and H-Beta filters in both 1.25" and 2" eyepiece versions.

Some dealers carry a few filters. We carry 38. We have one that's right for you.

There's nothing mysterious about *this* Sphinx!

The **Vixen Sphinx** telescopes and mounts take the mystery out of go-to astronomy. You don't have to know Messier, NGC, or IC numbers to have your scope find deep sky objects.

Vixen Star Book hand control showing star chart display

Simply move the crosshair cursor over the object displayed on the Star Book hand control's 4096-color LCD star chart screen. Push a button and the Sphinx mount moves to that object. Zoom-In/Out buttons for the star chart display also control the motor speed. As you zoom in on an object displayed on the screen, the motor speed automatically slows for more accurate control. Zoom out and the motor speed increases to cover large distances more quickly.

FL80SWT-SXW
3.1" f/8 fluorite apo Vixen refractor on Sphinx go-to mount
$3910

The Star Book's 4MB flash ROM memory can be updated from the Internet to keep you current with the heavens. And the easy-to-use Star Book can be used as a stand-alone star atlas to let you learn the skies anywhere, anytime.

The Sphinx go-to mount with Star Book controller is available separately for use with your own optics. It is also available in premium Vixen telescope/mount packages that range from a 3.1" f/5 refractor on a supremely portable tabletop go-to mount to big 8" reflectors and catadioptrics on full length field tripods.

You'll find full Vixen Sphinx details and prices on our **www.astronomics.com** website.

Everyone can afford CCD when cameras start at $249!

SAC7B cooled 24-bit color
$499

Low cost **SAC Imaging** CCD cameras finally make serious CCD imaging possible at sensible prices. Even the owners of small telescopes (such as the Meade ETX-90) can do serious CCD imaging with a very affordable SAC camera.

Whether it's short exposure lunar and planetary shots, long exposure deep space photos, black and white imaging, single-pass full color, tri-color with a filter wheel, or auto-guiding – there's an inexpensive SAC CCD camera to do it. You'll find full details and pricing on all of them on our website at **www.astronomics.com**.

Meade ETX Maks now come with tripod and Autostar!

5" ETX-125EC
$995, complete

Best-selling **Meade ETX Maksutov-Cassegrains** now include a heavy duty adjustable height tripod and Autostar computer (with a 30,223 star and object memory) for less than the former cost of the same components bought separately. A tripod is a costly option with the competition's 4000-object memory 4" go-to Mak. Prices start at only $595 for a full-featured 3.5" go-to scope with everything you need to start observing as soon as you get it. Each 3.5" to 5" ETX has a tripod, computer, eyepiece, finderscope, and more. Optional UHTC (Ultra High Transmission Coatings) can give you images up to 20% brighter so you can see 20% more of the Universe.

Authorized Meade Dealer

Best-selling Meade ETX Maksutovs, now better than ever – and they're in stock!

Get a go-to *now.* We'll ship your Celestron from stock.

Celestron Advanced Series scopes put multicoated optics on an easy-to-use go-to mount. From a 5" SCT (with optics so good that NASA flies them on the Space Shuttle) to a 10" reflector, there's a Celestron go-to that's right for you and your budget. And state-of-the-art Starbright XLT multicoatings are available as an option on the bigger SCTs. Scopes include:

a 6" Newtonian reflector	**$799^{00}**
an 8" Newtonian reflector	**$1019^{00}**
a 6" achromatic refractor	**$1069^{00}**
a 5" Schmidt-Cassegrain	**$1099^{00}**
a 10" Newtonian reflector	**$1199^{00}**
an 8" Schmidt-Cassegrain	**$1359^{00}**
an 8" SCT with XLT coatings	**$1514^{00}**
a 9¼" Schmidt-Cassegrain	**$1779^{00}**
and a 9¼" SCT with XLT coatings	**$1999^{00}**

Each Advanced Series go-to has a heavy duty adjustable height tripod with 2" diameter steel legs instead of the lighter aluminum legs used on competitive scopes. Their computers can find and track over 45,000 stars and objects for you, compared to 30,000 for the competition. These Celestrons ship from *our* stock. You don't have to wait a long time for a manufacturer to build and ship your scope to you.

Celestron C 8 S-GT 8" go-to
$1359
($1514 with optional XLT coatings)

CELESTRON

Eyepiece cases start at only $\$2^{49}$!

These bolt-type containers keep your eyepieces free from dew and dust. Foam inserts cradle the eyepieces to protect against accidents. Our website at **www.astronomics.com** lists which specific eyepieces fit into which containers.

42mm x 60mm holds most Celestron Omni and E-Lux, Meade Series 3000, and TeleVue Plössls.	**$2^{49}**
52mm x 80mm holds TeleVue Radians, Nagler Type 6, most Barlows, large Celestron Ultimas, etc.	**$3^{49}**
65mm x 80mm holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc.	**$3^{99}**
65mm x 120mm holds longer Barlows, 55mm Plössl, 22mm and 27mm Panoptic, etc.	**$4^{99}**

Do Celestron CGE go-to scopes have the perfect mount for astrophotography?

$4149
Celestron CGE1100

Astrophotography with a fork-mounted go-to Schmidt-Cassegrain has its drawbacks. You can't use its altazimuth mount to take long exposure deep space photos without adding a costly equatorial wedge or field derotator. Use a wedge and you can't image near the celestial pole or the southern horizon, and tube vibrations can become a problem. Use a field derotator and you lose periodic error correction and can't image near the zenith. In larger apertures, fork-mounted scopes usually require two people to set up.

Celestron CGE German equatorial go-to scopes solve these problems. Even the big 14" CGE1400 can be set up by only one person. The CGE mount can reach all parts of the sky, without adding a costly wedge or field derotator. And German mounts are known for being virtually vibration-free.

Celestron CGE scopes with standard Starbright multicoatings are available as complete go-to systems in apertures from 8" to 14", or as a go-to mount only. You can add a GPS kit for only $225. You can even add state-of-the-art Starbright XLT coatings for Celestron's brightest images ever.

Only $995 for a 5" GPS-ready Celestron SCT!

The **Celestron NexStar 5i** is the *only* 5" telescope to have a fully automatic GPS go-to computer available as an option. No other 5" scope has GPS! The NexStar 5i has a computer hand control with a 45,000+ star and object database, tripod, finder, eyepiece – everything you need to start observing immediately!

Multicoated optics are *standard equipment* with the Celestron NexStar 5i, not an option as with other scopes. NASA uses Celestron 5" multicoated optics on the Space Shuttle. Don't your eyes deserve the same premium image quality? **$995**

the Nexstar 5i is shown with optional photography accessories

NexStar 5i

CELESTRON

The Celestron NexStar 8i GPS-ready 8" go-to SCT costs only $1379!

The $1379 **Celestron NexStar 8i** costs hundreds less than other comparably-equipped 8" go-to scopes. You can start observing with it as soon as you take it out of the box. Its computer has a library of 45,000+ stars and objects it can find for you. It has a tripod, red dot finder, and eyepiece. Starbright multicoatings are standard equipment, not an optional extra. If you want GPS (an unavailable option on other scopes), it's only $199. The NexStar 8i is enough scope to keep you observing for the rest of your life, at a price that leaves most other scopes behind.

the Nexstar 8i is shown with all standard accessories

NexStar 8i
$1379

Takahashi premium apo optics are on sale!

If there's anything better than the superb optical perfomance of a **Takahashi** *fluorite apochromatic* refractor, it's the speed at which you can get premium Takahashi optics from our stock.

Even better than the fast delivery are the special sale prices on Takahashi's best-selling optical tubes. You can save as much as $2334 if you act now!

The 3.1" **FS-78** fluorite doublet optical tube is on sale for **$1195!** It's regularly $1379, so you save $184!

Takahashi's unique 90mm f/5.6 **Sky 90 II** is on sale for **$1849!** Regularly $2279, you save $430! With dew shield retracted, this fluorite apo is less than 14" long! *Sky & Telescope* called it "an ideal travelscope for mobile observers, providing maximum performance at minimum size."

FSQ-106N optical tube, $3475.

EM-2S mount and tripod, $2229.

The best-selling 4" **FS-102** fluorite doublet optical tube is on sale for **only $1895**! Regularly $2349, you save over $450!

The 5" **FS-128** fluorite doublet optical tube is **only $4495**! Regularly $5249, you save over $750!

Finally, the big 6" **FS-152** fluorite doublet optical tube is on sale for **only $6995**! Regularly $9329, you save $2334!

We also stock the 22" long Takahashi **FSQ-106N** 4-element f/5 4" *dual fluorite* 4" focuser astrograph apo refractor OTA, shown on an optional mount to the left.

If you want a premium apo refractor at a money-saving sale price, and you want it without a lo-o-o-ng wait, the refractor you want is a Takahashi from ***astronomics***.

24-Hour FAX line: (405) 447-3337   Our e-mail address: questions@astronomics.com
Our multiple award-winning Internet address: www.astronomics.com

STORE HOURS: 9-5 Monday thru Friday. Our telephone lines are open 9 to 6 CST, Monday thru Friday, and most Saturdays from 12 to 5.
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No credit card surcharge. $6.95 minimum freight.   All returns less freight.   Restocking fees apply to returns for credit and to merchandise returned used or damaged.

ASK ASTRO

Planetary rings, iron star

PLANETARY RINGS

Are all ring systems around planets in line with the planet's equatorial plane? If so, does this indicate some interconnection between the two things?

— **RICHARD SNYDER,** SILVER CITY, NEW MEXICO

Some three centuries ago, when Dutch astronomer Christiaan Huygens first saw that Saturn had rings, he published his discovery as an anagram. This let him avoid giving the secret away while retaining proof of his discovery. He described the rings as "A thin, flat ring, nowhere touching, and inclined to the ecliptic."

The ecliptic is the orbital plane of Earth, which also lies close to the orbital planes of most of the other planets as well. It struck Huygens as remarkable both that the rings were not in the same plane as all the planets and that the rings nowhere touched Saturn.

Better telescopes have revealed the reason the rings don't lie in the orbital plane of Saturn is that they, plus the small moons since discovered as well, all lie in Saturn's equatorial plane. In fact, the ring systems of the four gas giant planets — as different from each other as they are — all share this characteristic.

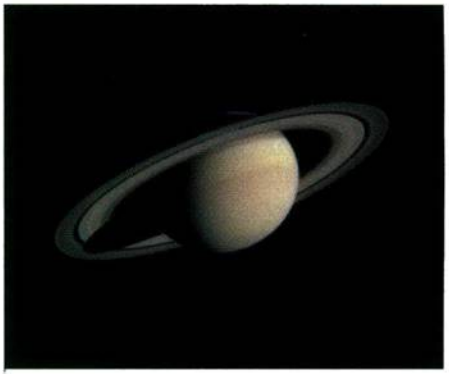
Learning a little more makes the situation even more puzzling. The equator of Saturn, of course, is pierced at a right angle by its polar axis, around which the planet spins. Earth's own North Pole points close to (but not at) the star Polaris. Because of tidal tugging on the body of Earth from the Sun, Moon, and planets, the direction of our planet's North Pole traces a small circle on the sky every 26,000 years. Saturn's pole makes a similar circle but over millions of years. And as a planet's rotation axis wanders around the sky, its equator naturally follows along.

But how can a thin, flat, detached ring of icy boulders, not to mention all those small moons, "know" that Saturn's equatorial plane is changing position? Why don't these bodies all get left behind?

The answer is subtle. In reality, all planets have slightly flattened shapes — and Saturn is especially flattened, or oblate, because of its fast spin and low density. Oblateness makes the strength of a planet's gravitational pull vary with distance differently than it would for an idealized body whose mass is concentrated into a mathematical point. The effect is magnified for rings and moons of a gas giant because they orbit so close to the planet.

Oblateness ensures that any small deviation from a perfectly circular orbit — and all real orbits are slightly elliptical — makes particles move just a little faster when they are in close than they would when farther away, compared to what Newton's laws predict for gravity from a mathematical point-mass. This means that when the particles return to their apocenter, or farthest point from the planet, they aren't at quite the same longitude as they were just one orbit before.

To put this another way, the orbit isn't really a closed ellipse; instead it slews around the planet slowly, with the apocenter's longitude gradually increasing. This twisting is called orbital precession. A similar effect occurs for the longitude where a particle or moon crosses the equator's plane with a tiny, but finite, vertical motion. The time it takes an orbit to slew completely around a planet is called the orbital precession period. For Saturn's rings and moons, this takes months.



RINGS ENCIRCLE all the gas-giant planets of the solar system, orbiting in their equatorial planes. What holds the rings there is each planet's widened waistline. NASA/CASSINI

The effect of orbital precession is that particles follow the planet's equator as it changes position. Because the precession of an orbit takes far less time than the time it takes the planet's pole (and equator) to move significantly, the rings and moons can keep up.

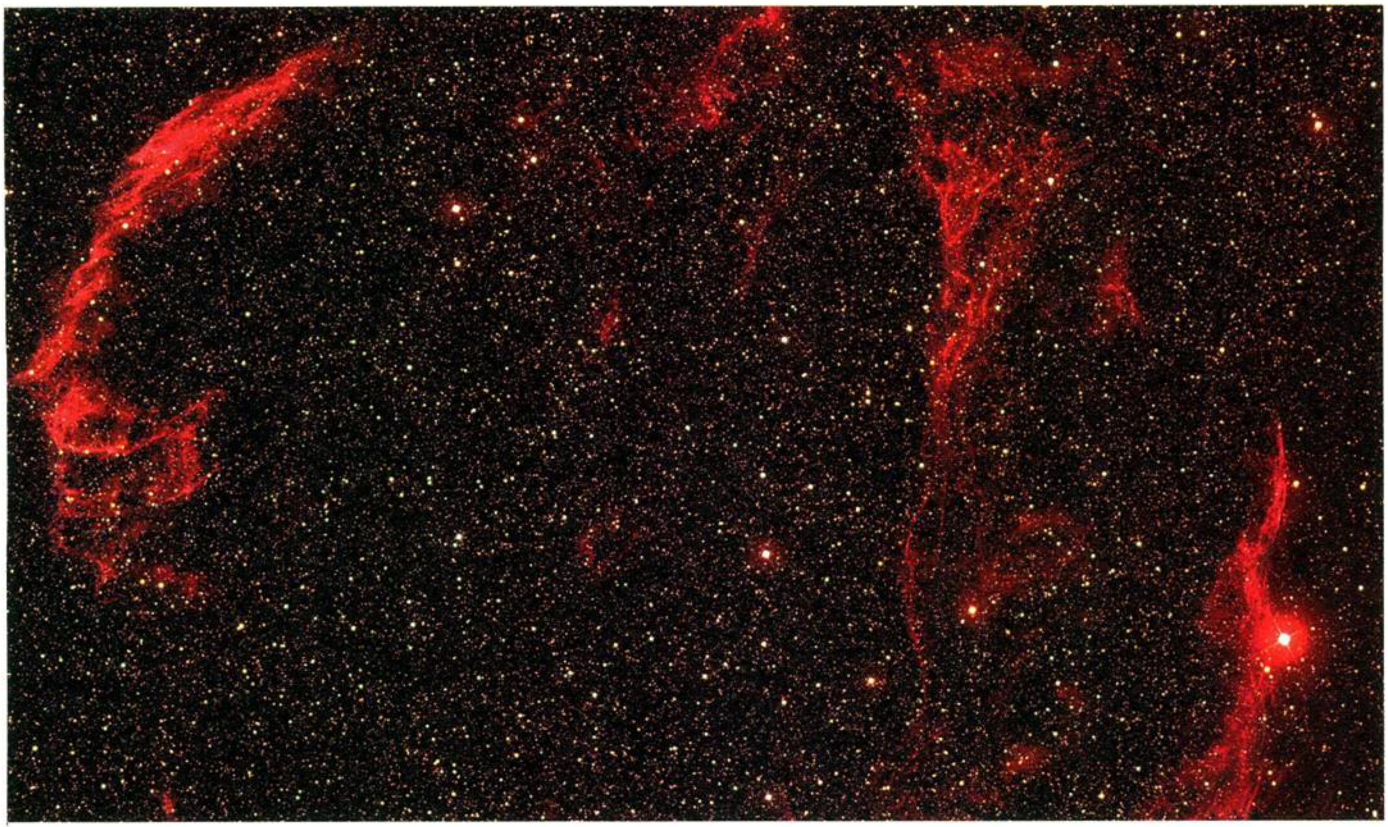
In fact, rings are more prone to this effect than moons are because a swarm of particles can dissipate random velocities through collisions and, thus, keep returning to the average plane of motion: the equatorial plane. The outcome is that we always see ring systems lying in, or extremely near, the equatorial planes of all four gas giants. — **JEFF CUZZI,** NASA AMES RESEARCH CENTER

IRON STAR

I've read a number of times that the large and stable nucleus of iron is the final product of stellar fusion reactions before a star collapses, or words to that effect. Where, then, do the many heavier elements originate from?

— **TONY REDDING,** BRISBANE, AUSTRALIA

The Big Bang gave us hydrogen and helium with a salting of lithium. The stars



IF THERMONUCLEAR FUSION in stars stops with iron, what makes heavier elements? The answer, in the Cygnus Loop Nebula and other supernova remnants, is blowing in the wind. JASON WARE

gave us the rest of the elements.

A star begins life with 90 percent hydrogen and 10 percent helium (with only 0.1 percent heavy elements given it by previous stellar generations). A star supports itself by nuclear fusion in its deep, hot core, which generates the energy that makes it shine and keeps the core from contracting under the force of gravity.

As the star ages, it first converts hydrogen to helium (a process that occupies over 80 percent of the star's lifetime), then helium to carbon and oxygen. A lower-mass star like the Sun stops there, sloughs off its envelope as a planetary nebula, and dies as a white dwarf. A high-mass star born with greater than 10 solar masses will continue to fuse elements in its core: carbon and oxygen to neon, magnesium, and oxygen; these to silicon and sulfur; then these to iron, the end of the line.

As each "nuclear burning" stage is completed, the activity moves outward into a shell around the next stage, so the star becomes layered inside, with a great (but inert) hydrogen envelope surrounding the interior. Convection can dredge up some of the byproducts of fusion to the star's surface, where the stellar wind can fling the new chemical elements (helium, carbon, nitrogen) into space.

Most of the very heavy elements, however, are not made by energy-generating processes, but by the capture of neutrons. (Neutrons have the mass of protons but lack electrical charge and are easily absorbed by atoms.) After neutrons are captured, they decay into protons and electrons, the latter being ejected. This changes a given element to the next-heavier one in the periodic table.

Two neutron-capture processes exist: the slow (the s-process), in which neutrons are captured leisurely; and the rapid (the r-process), in which they are captured like machine-gun bullets. The s-process works in all evolving stars and creates such elements as strontium, zirconium, lead, and many others. These are lofted to the stellar surface and lost to space.

The r-process is associated (in ways not yet understood) with iron-core, high-mass supergiant stars. When one of these stars reaches the end of the line at iron, its core collapses and turns into a tiny ball of neutrons. This is a neutron star and pulsar-to-be. The energy generated in the collapse blows the rest of the star apart in a supernova explosion.

In the heat of the exploding stellar envelope, violent nuclear burning creates all the elements up to and a bit beyond iron. The r-process then takes over and creates the rest, including nearly all the gold and silver in the universe and all the really heavy stuff like uranium.

It's important to note that the original iron core does not get out. Instead, it provides the energy for the explosion in which iron and other elements are made.
— JIM KALER, UNIVERSITY OF ILLINOIS,
www.astro.uiuc.edu/~kaler/sow/sow.html

Comets C/2001 Q4 and C/2002 T7 stand poised to deliver great shows this spring.

/// TEXT BY CHARLES S. MORRIS /// ILLUSTRATIONS BY ROEN KELLY

A tale of two comets

Seeing one naked-eye comet in a year is a treat. Seeing two brings a thrill to comet observers everywhere. So this spring promises a thrilling ride for skywatchers as two bright comets make their long-awaited treks through the inner solar system. Both comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR) were discovered well over a year ago. The intervening time has been filled with hope, anxiety, and anticipation. Will either of these become the next Hale-Bopp, or will they flop like Kohoutek?

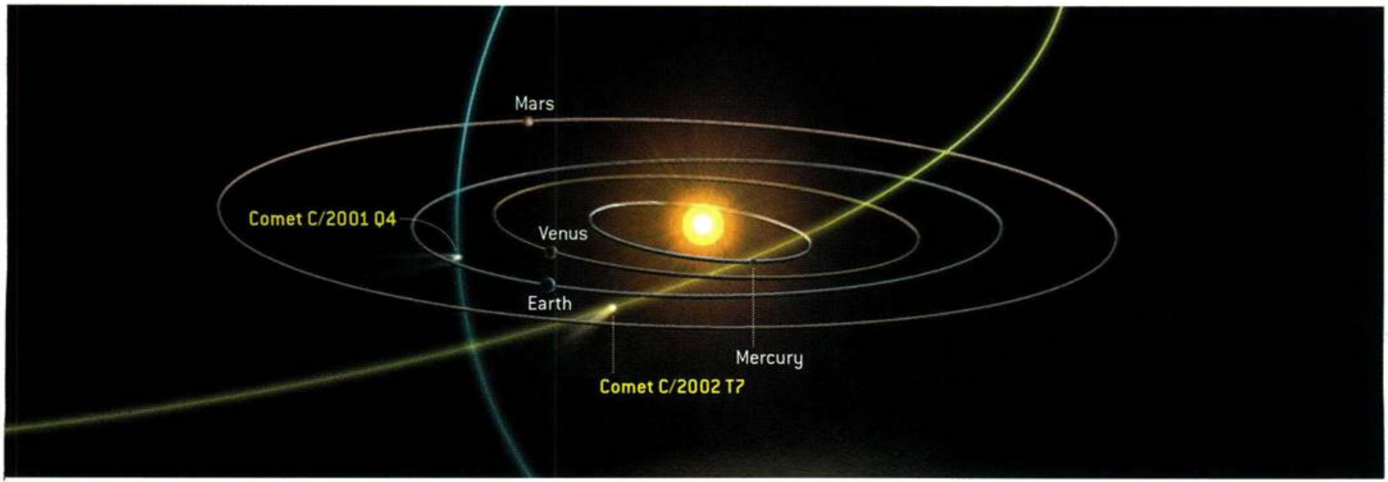
Survey programs first found these comets when they were still quite faint. The Near Earth Asteroid Tracking (NEAT) system at Palomar Observatory discovered C/2001 Q4 on August 24, 2001, when it glowed at 20th magnitude and lay more than 10 astronomical units from the Sun. (One astronomical unit, or AU, is the average distance between the Sun and Earth, about 93 million miles.) More than a year later, on October 14, 2002, the Lincoln Near Earth Asteroid Research (LINEAR) program at White Sands, New Mexico, discovered C/2002 T7. The comet then glowed at magnitude 17.5 at a distance of nearly 7 AU from the Sun. The comets' orbits suggest both hail from the distant Oort Cloud and are making their first passages through the inner solar system.

The orbits largely determine what people will see. C/2001 Q4 has remained deep in the southern sky during recent months, while C/2002 T7 has favored the Northern Hemisphere. During their peak observing periods this spring, both comets will be positioned best for Southern Hemisphere viewers, but northerners should expect excellent views of C/2001 Q4.

A NICE TAIL already was forming on 9th-magnitude Comet C/2002 T7 back in December 2003. MICHAEL JÄGER AND GERALD RHEMANN

The distance of a comet from both the Sun and Earth also plays a key role in its visibility. C/2002 T7 reaches perihelion, its closest approach to the Sun, on April 23 at a distance of 0.61 AU. Its closest approach to Earth comes on May 19 at a distance of 0.27 AU. C/2001 Q4 reaches perihelion (0.96 AU away from the Sun) on May 15 and comes closest to Earth (0.32 AU) on May 7. Because a comet's tail typically grows the closer it gets to the Sun, you can expect C/2002 T7 to develop a more impressive tail.

Many factors determine whether a comet will sizzle or fizzle, and perhaps the most critical one is how bright it will get.



HEADING IN FROM THE OORT CLOUD, comets C/2001 Q4 and C/2002 T7 are traversing the inner solar system on orbits that lie well outside the plane of the planets. The positions of the comets and planets are shown for May 15, when both comets appear near their brightest. After putting on excellent shows, both comets will head back to the outer regions of the solar system, never to be seen again.

To predict the brightness of each comet, I analyzed a subset of magnitude estimates made by experienced observers for these comets so far. The estimates were submitted to the *International Comet Quarterly* and provided to me by its editor, Daniel Green. These brightnesses can be represented by the following equations:

C/2001 Q4 (NEAT):

$$m_1 = 3.7 + 5 \log \Delta + 10 \log r$$

C/2002 T7 (LINEAR):

$$m_1 = 4.26 + 5 \log \Delta + 9.7 \log r$$

where m_1 is the observed magnitude, Δ is the distance between the comet and Earth in AU, and r is the distance between the comet and Sun in AU. These equations, which I used to make the brightness forecasts below, could be significantly in error by the time of perihelion. The predictions show a peak brightness of magnitude 0.6 for C/2002 T7 and magnitude 1.1 for C/2001 Q4. Even if the rate of brightening decreases significantly, however, we should still get a fine show. A reasonable worst-case scenario gives T7 a peak magnitude of 2.0 and Q4 a peak magnitude of 3.0.

Observing C/2001 Q4 (NEAT) Southern Hemisphere

During April and early May, C/2001 Q4 remains the near-exclusive property of those south of the equator. During much of April, the comet will be circumpolar — meaning it never sets — for those in most of Australia, New Zealand, southern Africa, and southern South America. For the first 24 days of April, the comet's declination hovers between –60° and –66°. Its eastward trek against the starry background keeps its solar elongation at a comfortable 70° or more.

The comet, however, will not be high in the sky as it rotates under the pole each night. At the beginning of April, Q4 stands about 25° high at the end of evening twilight as viewed from Sydney, Australia. It achieves a similar elevation at the beginning of morning twilight. By April 24, the comet lies 40° high in the evening sky. The comet's brightness also should increase during this period, from about magnitude 4.9 to 2.4.

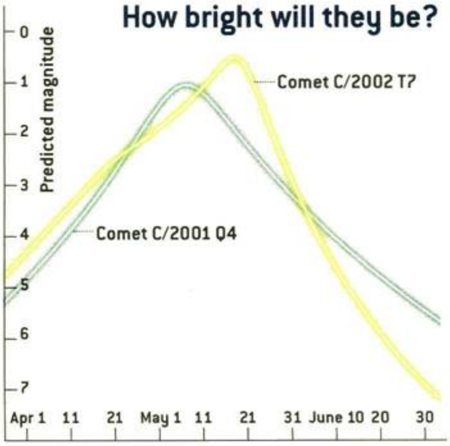
To avoid the nearly Full Moon during the first few days of April, observe before morning twilight starts to paint the sky.

COMET C/2002 T7 (LINEAR) should become the brightest comet with the longest tail to grace Earth's sky since Hale-Bopp amazed us in 1997. MICHAEL JÄGER AND GERALD RHEMANN

The comet then lies about 7° north of the center of the Small Magellanic Cloud, the Milky Way's companion galaxy. The Moon interferes with evening viewing until April 7. A two-week prime observing period follows until the Moon begins to limit dark-time observing again on the 22nd.

The period around Full Moon in early May should not discourage people from observing. Q4 travels rapidly northward during this time, moving high (about 60°) in the evening sky. The comet passes the 1.5-magnitude star Adhara (Epsilon [ε] Canis Majoris) on May 4 and the 1.9-magnitude star Wezen (Delta [δ] CMa) a day later. On May 7, the comet passes 1° from the bright open star cluster M47 (and also near its neighbor, M46). At about this time, interference from the Moon starts to abate and Southern Hemisphere observers will be treated to a comet near its peak brightness (magnitude 1.1) and with a significant tail. Another two-week period of prime observing then begins with the comet fading slowly and sinking lower in the sky. This coincides with the comet's rapid motion northward. Over the 25-day period starting May 2, it moves from –40° to 40° in declination.

By the end of May, the comet has faded to magnitude 3.3 and stands only 9° high at the end of twilight as seen from the latitude of Sydney. It will be lost totally by mid-June, although the main show will be over by then.

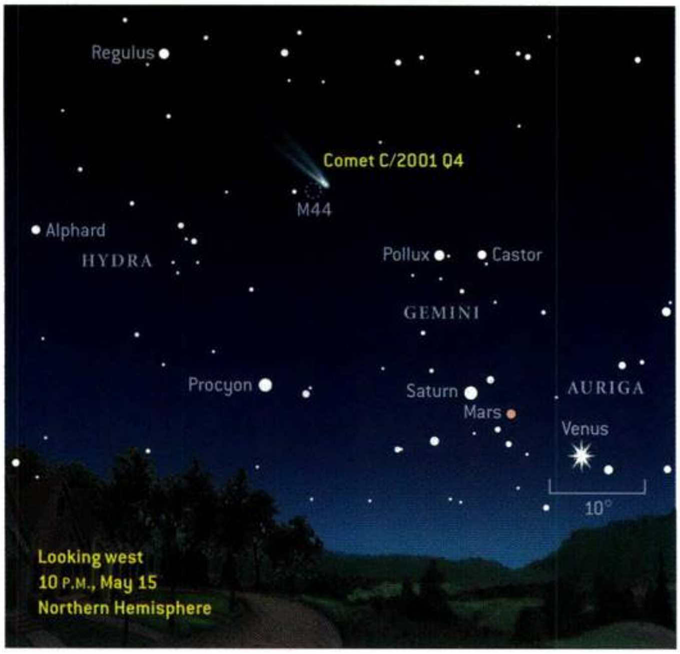


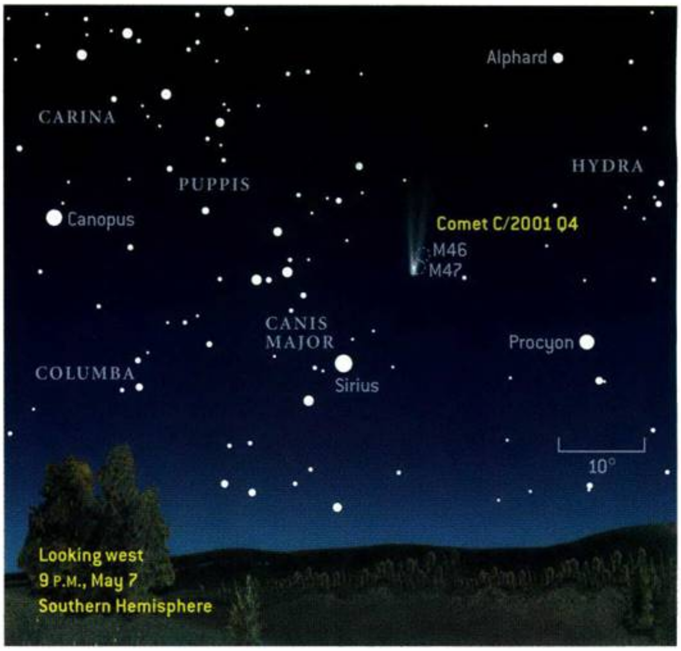
IF PREDICTIONS HOLD TRUE, C/2002 T7 should peak near magnitude 0.6 in mid-May and C/2001 Q4 at magnitude 1.1 in early May.

Northern Hemisphere

Northern observers no doubt will be eagerly awaiting Q4's appearance. Those in Hawaii may glimpse it as early as April 29. For those at the latitude of Los Angeles, the comet peeks above the horizon on the evening of May 3, but the nearly Full Moon then interferes and makes observations near the horizon difficult. The comet already will be near its peak brightness, but moonlight and atmospheric extinction most likely will wipe out the tail.

The evening of May 6 should provide the first good view of the comet from most of the United States. From Los Angeles, it will stand about 15° above the horizon; it will appear slightly lower from





the northern tier of states. Dedicated astrophotographers will have a chance to capture Q4 near M47 and M46 that evening. The comet's tail also should reach its maximum length then.

The comet climbs higher in the sky with each passing evening, reaching an altitude of more than 40° by mid-May. This period will be the prime viewing time for North American observers. On May 15, 2nd-magnitude Q4 skirts 1° from the center of the Beehive star cluster (M44). Although this occurs during daytime for American observers, the naked eye and binoculars should provide splendid views of the comet with its tail and the nearby Beehive on the evenings of May 14 and 15. Views of the comet through a telescope should show a bright, nearly stellar condensation surrounding the comet's nucleus, with the tail(s) streaming away from the coma. If the comet has little dust, the coma will appear round and have a bluish tint. If the comet is dust-rich, the coma will have a parabolic shape and appear white.

The last chance for a great naked-eye view of Q4 will be on the weekend of May 22, when the comet should glow around magnitude 2.5. It will be well placed in the evening sky then and should be a pretty sight through either binoculars or a small telescope. By Memorial Day weekend, the nearly Full Moon will interfere with the 3rd-magnitude comet, but telescopes and binoculars will still give observers rewarding views.

Dedicated comet observers at dark-sky locations should be able to follow the comet with the naked eye until the Moon interferes in late June. During June, Q4 becomes a northern circumpolar object and remains visible all night long. It will remain circumpolar into 2005. Observers with binoculars should be able to track it at least into September, and telescopes might show it into 2005.

Observing C/2002 T7 (LINEAR) Northern Hemisphere

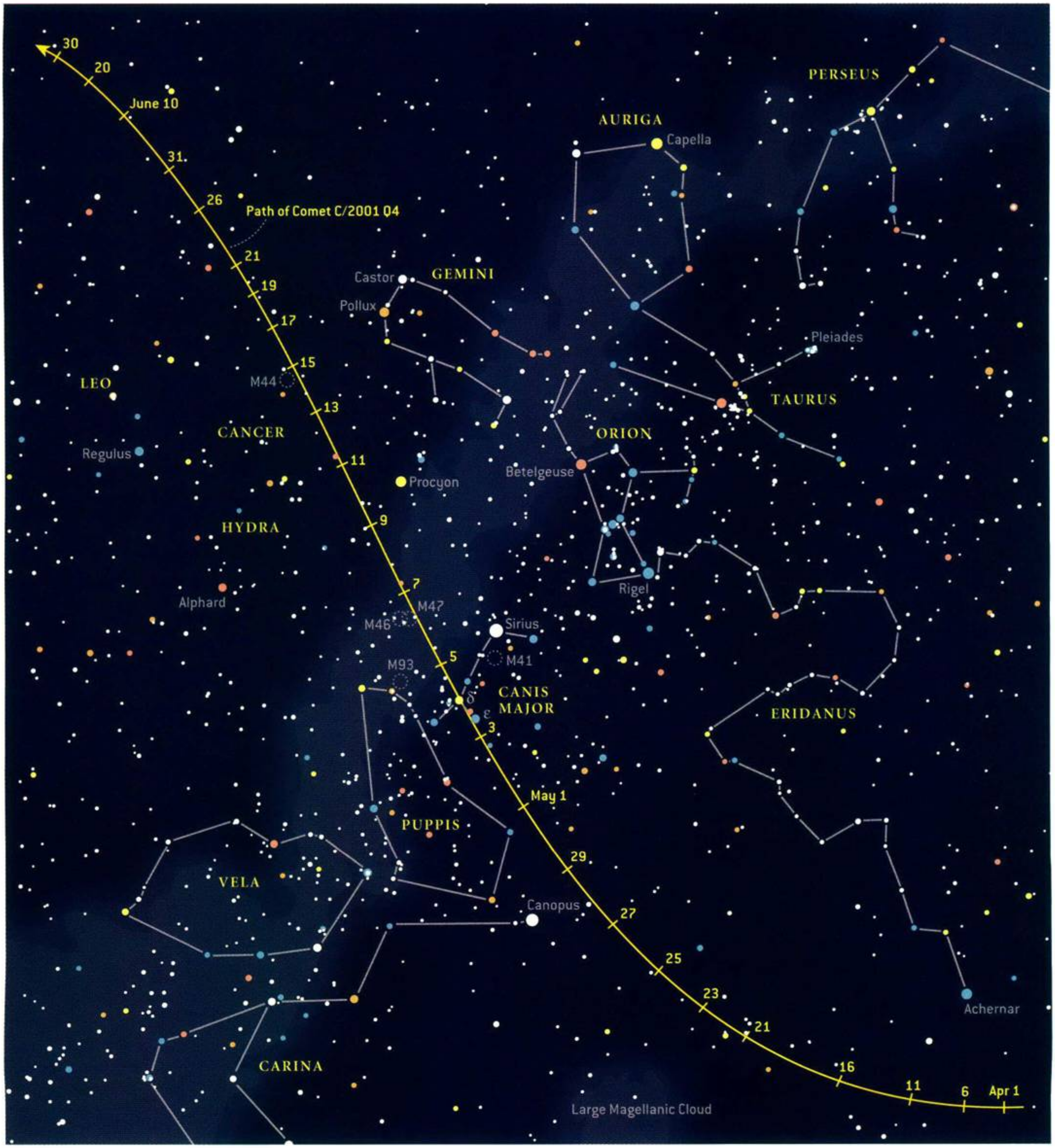
This comet will prove more of a tease than a show for observers in the Northern Hemisphere. Although it has lingered up north for much of this apparition, it moves south just as its performance gets good. After plunging into solar conjunction in early March, T7 will disappear for observers north of about 35° latitude who want dark-sky views. Those at or south of 35° latitude, however, have a chance to glimpse the comet as it becomes a naked-eye object. The only caveat: You'll need an unobstructed view of the eastern horizon.

For observers in the mountains around Los Angeles, for example, T7 pokes above the horizon as morning twilight begins on April 20. Although only 1° high, the comet rises several more degrees before the growing twilight swallows it. And it should be bright enough, at magnitude 2.6, to shine through the gathering dawn. Fortunately, the tail precedes the comet as it rises. During the following two weeks, the comet remains barely visible, achieving a maximum elevation of 3° at twilight's start. The comet should brighten to about magnitude 1.8 during this time. The best views will come prior to May 3, while the Moon stays out of the morning sky.

COMET C/2001 Q4 lay deep in the southern sky during most of its apparition but will sweep north at its peak in May. GORDON GARRADD

The situation improves farther south. By April 11, observers in Miami will pick up T7, which reaches a maximum altitude of 7° in late April. In Hawaii, the comet achieves an elevation of 11° at the end of April.

By the middle of May, T7's rapid eastward motion carries it from the morning into the evening sky. It reappears very low in the west-southwest after nightfall in the first half of June. On the evening of June 4, you can catch it just below the 2nd-magnitude star Alphard in Hydra. The comet should glow around magnitude 3.9


30
20
June 10
31
26
Path of Comet C/2001 Q4
21
19
17
15
13
11
9
7
5
3
May 1
29
27
25
23
21
16
11
6
Apr 1
LEO
Regulus
M44
CANCER
HYDRA
Alphard
Castor
Pollux
GEMINI
Procyon
Betelgeuse
AURIGA
Capella
PERSEUS
Pleiades
TAURUS
ORION
Rigel
Sirius
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M93
δ
ε
CANIS MAJOR
PUPPIS
VELA
CARINA
Canopus
Large Magellanic Cloud
ERIDANUS
Achernar

with its tail nearly parallel to the horizon. By the end of June, T7 has faded below naked-eye visibility and once again dips beneath the horizon.

Southern Hemisphere

The real show occurs south of the equator. At Sydney's latitude, the 3.4-magnitude comet should be visible as early as April 11. Its elevation in the morning sky increases approximately 1° per day during the next twenty days. The comet reaches its maximum elevation of 23° on May 7, when it shines at magnitude 1.5. Unfortunately, the nearly Full Moon interferes with the view then. During the next ten days, the brightening comet sinks ever lower in the morning sky.

As seen from the latitude of Sydney, T7 moves from the morning to the evening sky on May 17/18. It will be near its peak brightness, magnitude 0.6, for the next few days. On May 20, the comet stands 21° high in the western sky while 2nd-magnitude Q4 lies 22° high in the north. With the former comet north of the Sun and the latter south, the tails will point in dramatically different directions.

T7 begins to fade quickly at the end of May as it moves away from both the Sun and Earth. On May 23, it passes between Sirius and open star cluster M41. On the 25th and 26th, it travels between M93 and the M46/M47 pair. These open clusters should make a beautiful backdrop for wide-field photos of the 1.6-magnitude comet, despite the Moon's increasing presence. As May ends, T7 will have faded to around magnitude 3.0 and the nearly Full Moon will have stolen the comet's thunder.

In early June, as the Moon leaves the evening sky, the 4th-magnitude comet will drift past Alphard. By midmonth, T7 likely will have faded from naked-eye view. It should remain a binocular object until it once again dips into the solar glare in August. When the comet reappears in November, it should be a telescopic object glowing around 12th magnitude.

End of the tail

Most backyard observers want to know, first and foremost, how bright a comet will be and from where it will be visible. Yet often just as important to a comet's visual impact is whether it sports a long, bright tail. Unfortunately, this question proves difficult to answer precisely. A bright dust tail appears much more impressive than a gas tail, primarily because human eyes are more attuned to the yellowish sunlight reflected by the dust than the bluish emissions from the gas.

In general, the physical length of a comet's tail peaks a month or so after perihelion. However, what we see from Earth depends as much on the viewing geometry and the comet's distance as it does on the tail's length. The geometry for both spring comets is quite good, particularly for Southern Hemisphere observers.

For C/2001 Q4, the best geometry for seeing the tail coincides with the comet's closest approach to Earth in early May, a week or two before perihelion. Inbound comets at approximately 1 AU generally don't have significant dust tails. C/1996 B2 (Hyakutake) is a good example: It displayed a long gas tail but a minimal dust tail. The exception was C/1995 O1 (Hale-Bopp), which showed an impressive dust tail despite a perihelion distance similar to that of C/2001 Q4. However, Hale-Bopp was not your typical comet.

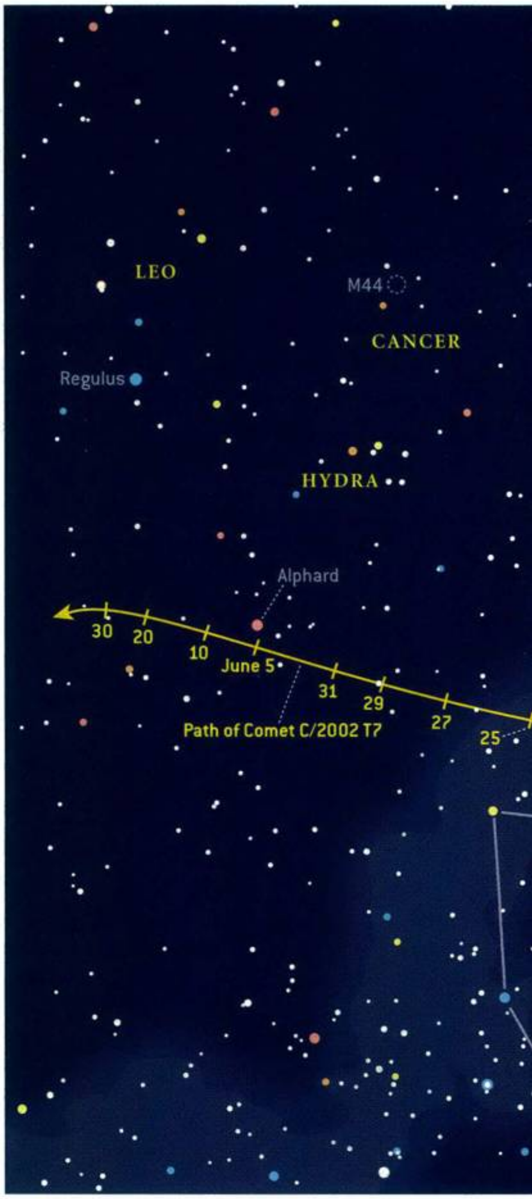
Charles S. Morris has observed comets for more than 30 years. He is associate editor of the *International Comet Quarterly* and has maintained the Comet Observation Home Page web site (encke.jpl.nasa.gov) for 10 years.

COMET C/2002 T7 posed in Triangulum for this image; it heads rapidly east at the peak of its apparition. MICHAEL JÄGER AND GERALD RHEMANN

C/2001 Q4 likely will develop a significant gas tail that may reach 10° or 15° in length during early May. If it sprouts a dust tail, it will curve to the south. The comet's distance from Earth doubles by the end of May, and the viewing geometry deteriorates. Even though the physical length of Q4's tail may increase during the month, from our vantage point, the observed tail length should decrease.

C/2002 T7 holds greater promise for a bright, beautiful tail because it approaches closer to the Sun. When viewed on mornings in late April, the comet will be a few days past perihelion but still about 1 AU from Earth. Despite this, a noticeable gas tail up to 10° in length and pointing straight up from the horizon should precede the rising comet. The dust tail will arc to the north and likely appear shorter because it curves away from Earth. The viewing geometry for the gas tail improves until May 2, when the comet's distance from Earth has dropped to 0.78 AU. Both tails should grow nicely during this period.

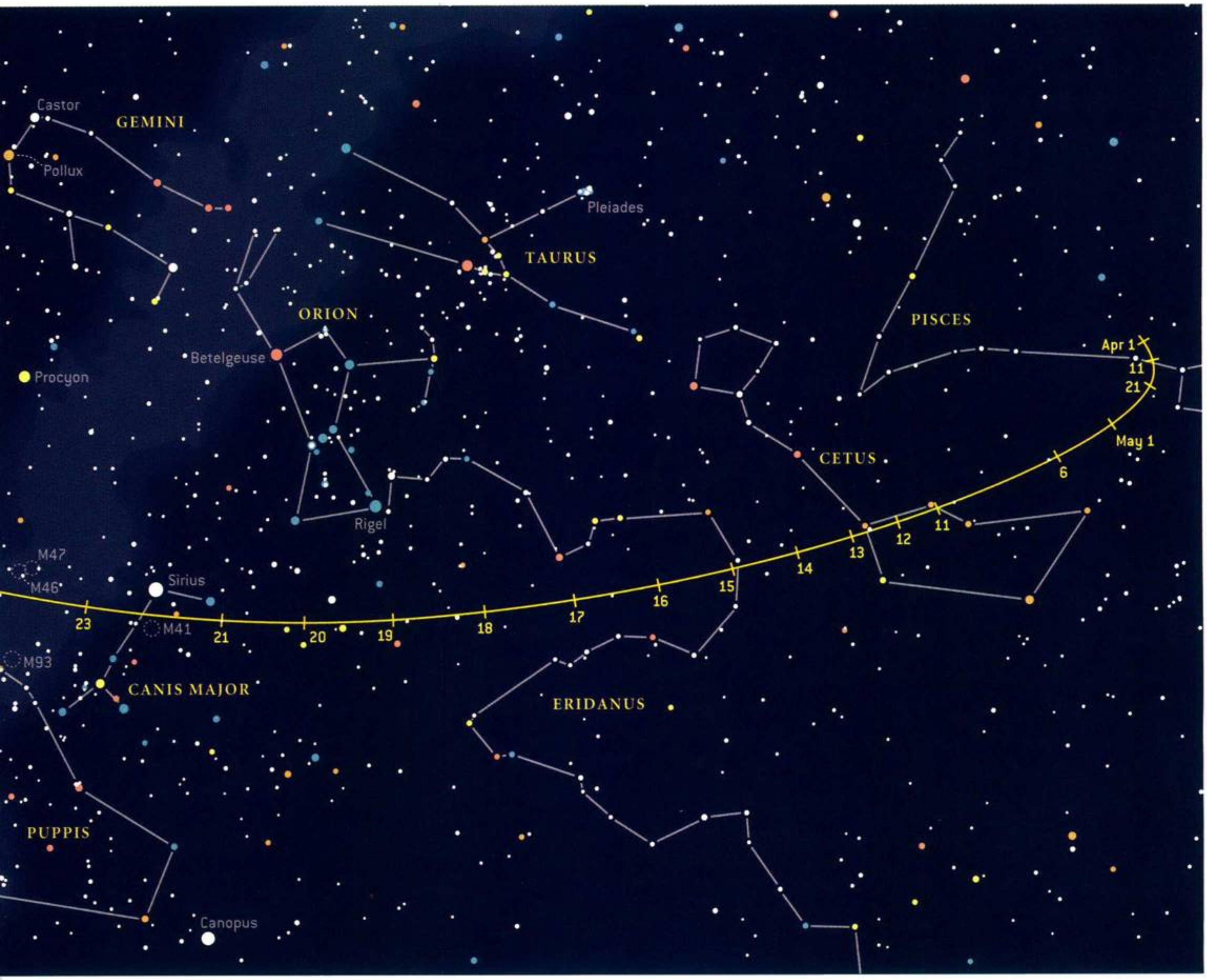
T7's swing into the evening sky in mid-May will cause a rapid shift in the position angles of its tails as the comet and Earth pass each other. The transition will lead to a significant foreshortening of both tails. However, the viewing geometry rapidly improves toward the end of the month, when the dust and gas tails should appear separate. The apparent tail lengths should peak just as the Moon enters the evening sky in late May, when lengths of 20° or more might be possible.



By mid-June, the dust and gas tails will seem to merge in the sky. Although the comet has faded dramatically by then, observers with sharp eyes at dark-sky locations may see a faint but long tail because this is the time when we view the dust tail at its most favorable geometry.

No one knows for sure what comets C/2001 Q4 and C/2002 T7 will do. There is little question they will glow bright enough to be seen with the naked eye from suburban and rural areas. And both may display conspicuous tails. The only way to know is to head out under the stars and see for yourself. Whatever they hold in store, 2004's spring comets should create their own special memories. ■

To find out what makes a comet sizzle or fizzle, visit www.astronomy.com/toc


Castor
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TAURUS
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Apr 1
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CETUS
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Sirius
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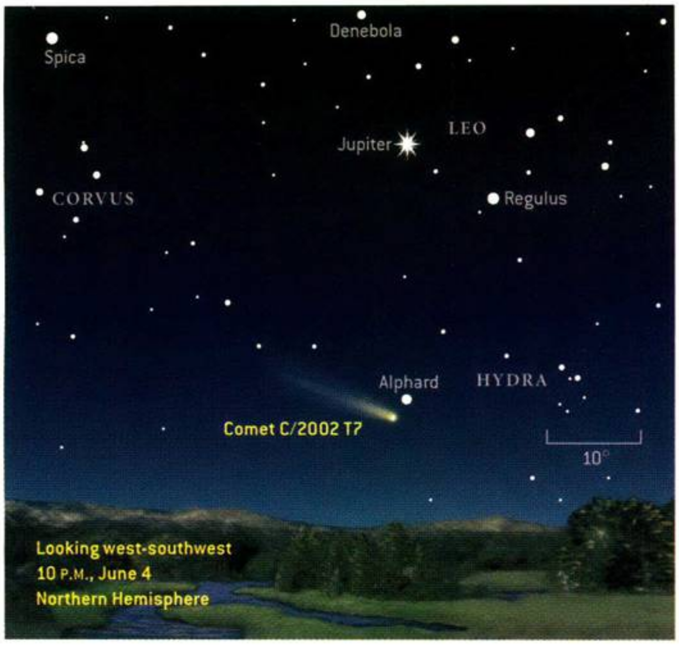
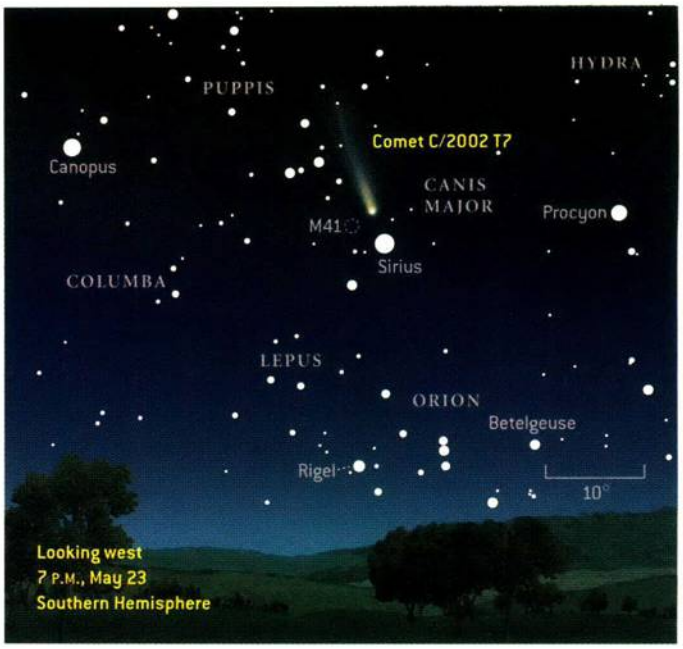
M93
CANIS MAJOR
ERIDANUS
PUPPIS
Canopus


Spica
Denebola
LEO
Jupiter
CORVUS
Regulus
Alphard
HYDRA
Comet C/2002 T7
10°

Looking west-southwest
10 P.M., June 4
Northern Hemisphere


HYDRA
PUPPIS
Comet C/2002 T7
Canopus
CANIS MAJOR
Procyon
M41
Sirius
COLUMBA
LEPUS
ORION
Betelgeuse
Rigel
10°

Looking west
7 P.M., May 23
Southern Hemisphere

An innovative approach to video photography allows fireball hunters to scan the sky 24 hours a day. /// BY JIM GAMBLE

All-sky fireball network

In the black of the night it just catches the corner of your eye. A rapidly brightening, fast-moving ball of light trailing across the sky. You look skyward with a resounding "whoa!" as you witness the flight of a spectacular meteoric firework called a "fireball." Then the inevitable thoughts race through your mind . . . What was that? Did anybody else see it? Is there somebody keeping track of these things? In at least some instances, the answer is yes.

The network

It's known as the Sandia Fireball Network, and its purpose is to acquire multiple-camera recordings of bright fireball events. My association with the fireball network began in August 2000, when, as a television weather forecaster in El Paso, Texas, I pleaded with my audience for eyewitness accounts of an incredible fireball I had observed the night before. I received a call from Robert Liefeld at the physics department of New Mexico State University in Las Cruces, about 40 miles north of El Paso. Liefeld operates an all-sky camera there and provided me with a video of my fireball. Eureka! "I want one of these cameras," I told him. He put me in touch with Dick Spalding, and my El Paso station was up and running by January 2001.

The network, which now consists of about twenty relatively low-cost all-sky videocameras, spans five regions in western North America. Initial support for the fireball network was provided by Sandia National Laboratories located near Albuquerque, New Mexico, as an adjunct to a program funded by the United States Department of Energy. In the adjunct program, satellite-mounted visible-light flash detectors monitor the globe for atmospheric nuclear detonations. These space-based sensors routinely record between thirty and fifty bright fireballs per year. But the high altitudes of these satellites preclude obtaining information precise enough to determine the velocity and trajectory of atmospheric fireballs. One aim of the fireball network is to collect "ground truth" on events to establish where in the solar system larger impactors seen by the satellites may have originated.

ELP
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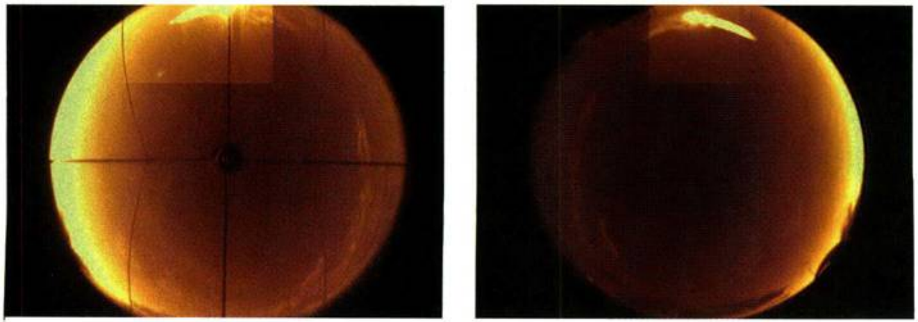
A BRILLIANT FIREBALL visible from the southwest of El Paso, Texas, on January 11, 2003, was captured on videotape. This event measured −13.9 in visual magnitude, the brightest event yet seen by the El Paso station of the all-sky Sandia Fireball Network. JIM GAMBLE



A −15-MAGNITUDE FIREBALL over southern Colorado was captured (left) by a mirror camera located at Sandia National Laboratories near Albuquerque, New Mexico. Despite an intense search of the projected landing area, no meteoric debris has been discovered yet. SANDIA NATIONAL LABORATORIES

THE SAME METEOR was imaged by another camera (right), also at Sandia, with a direct-vision fish-eye lens. Note that the fish-eye lens reverses the image. This is a minor drawback, much outweighed by the benefits of an unobstructed view. SANDIA NATIONAL LABORATORIES

How it all began

The idea for inexpensive fireball monitoring has its seeds in chance recordings of bright fireballs by security videocameras during the late 1990s. In these cases, the cameras, set up to monitor parking areas, happened to capture a fireball's flight reflected in the windshields and bodies of parked automobiles. Although the irregular shape of these surfaces resulted in distorted images, it was readily apparent to Dick Spalding and George Alder, both of Sandia Labs, that much could be achieved with a simple videocamera and good reflector geometry. By chance, in January 1998, an unusual outbreak of fireballs occurred over Colorado. Trying to cash in on that activity, Spalding and Alder hastily contrived a simple design employing a hemispherical safety mirror. They assembled and tested a garage-built prototype and began the Sandia Fireball Network.

Out of the starting gate

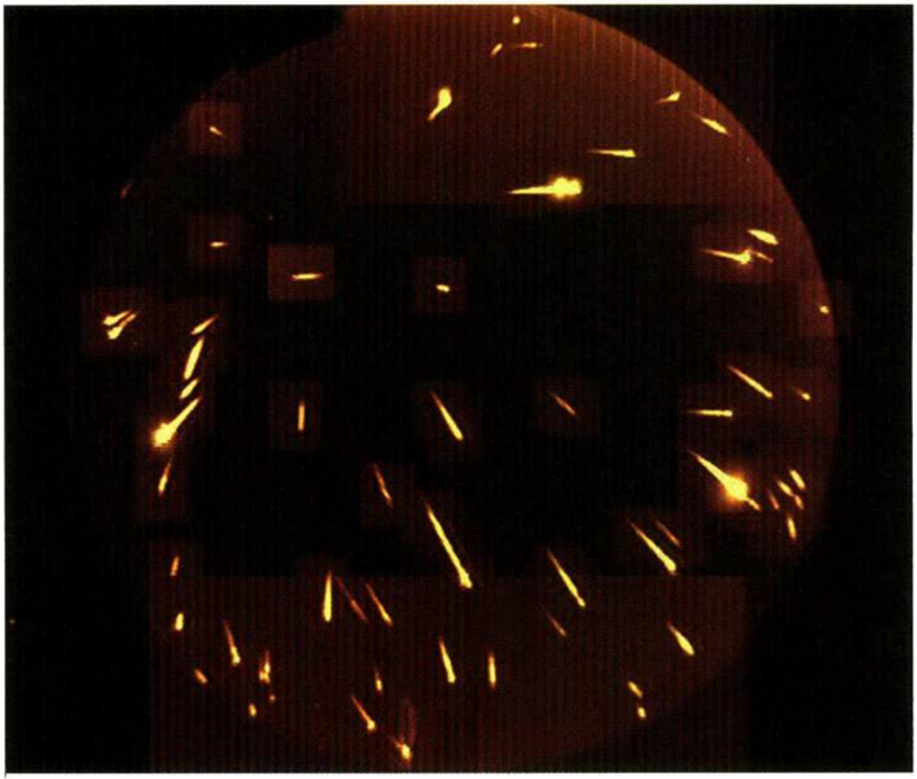
The initial all-sky camera design consisted of an 18-inch-diameter convex, acrylic, hemispherical safety mirror, with a black-and-white videocamera mounted above it facing downward. The camera was housed in a short length of 3-inch-diameter PVC pipe, capped at the top to keep rain out, but open at the bottom and supported by four aluminum legs.

An early concern was whether the cameras' optical parts would tolerate the Sun's reflected image for hours on end. That turned out to not be a problem, making it feasible to do 24-hour unattended operation and not simply nighttime monitoring of the sky. The setup proved to be robust, with both cameras and mirrors able to operate for years with little degradation. Another problem soon cropped up, however. Birds used the camera housing as an outhouse perch, so a cluster of long nails or screws was attached to the top of the housing cap pointing skyward. And this solution works — usually.

To support full-time operation, systems are equipped with three videocassette recorders, each programmed to record a specific 8-hour segment of the day. An operator changes all three tapes every 24 hours, and recorded tapes are archived. By April 1998, the first production camera systems were ready and not a moment too soon. A new center of fireball activity seemed to be developing above the Pacific Northwest. Spalding contacted Jeremy Tatum of the University of Victoria, British Columbia, Canada, whose name had been mentioned in one of the fireball reports, and asked whether he would be interested in finding hosts in that part of Canada for all-sky cameras. By June, three new systems had been deployed, one each at Courtenay, Nanaimo, and Victoria. Today, the network spans the western and southwestern United States as well as southwestern Canada.

Of bytes and brains

One of the difficulties encountered with the initially deployed systems was finding fireball occurrences on miles of videotape. Camera operators relied on eyewitness reports to know where to locate the fireballs on their tapes. Playing back and searching recorded videotapes was a tedious and mind-numbing task. A few years ago, however, a chance to improve the search process arose.

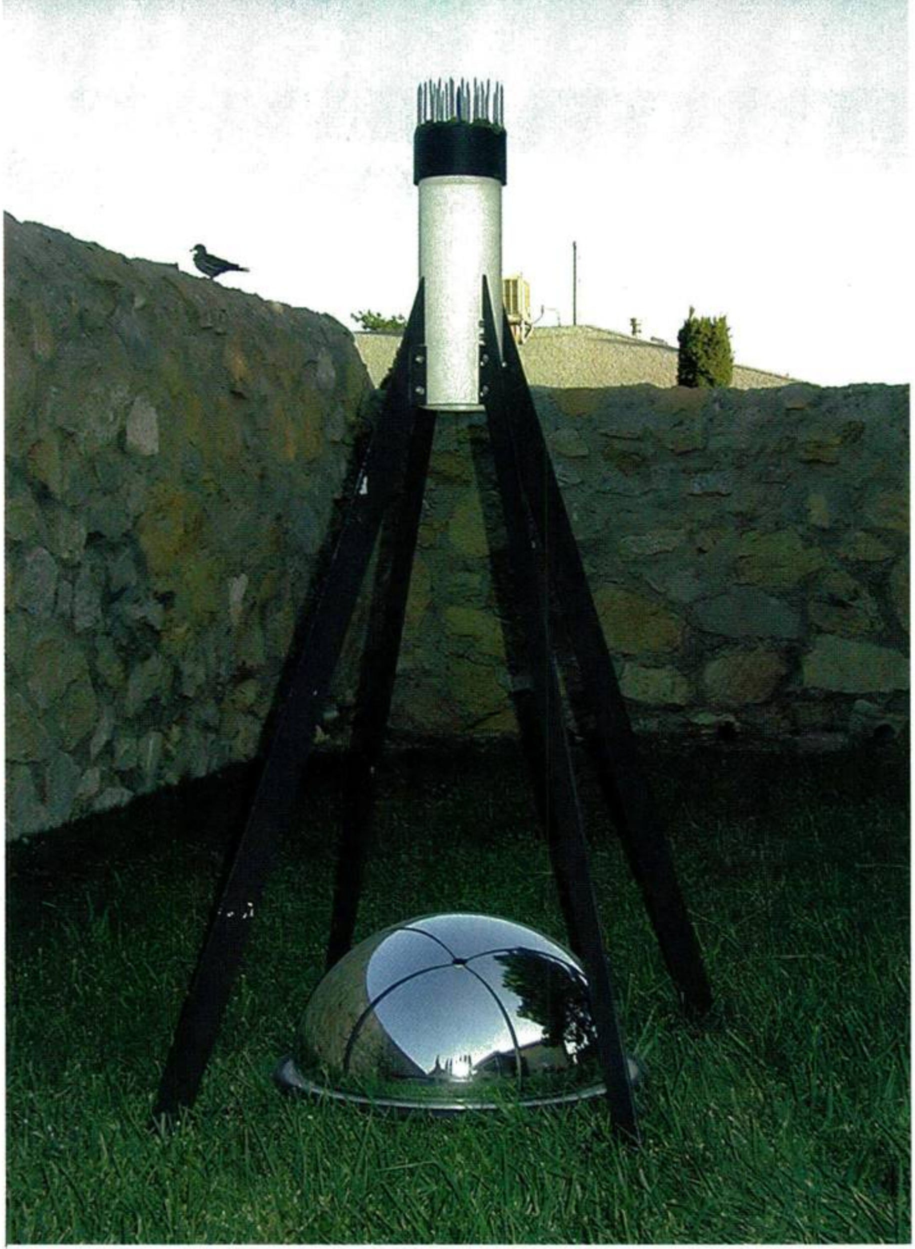


THIS COMPOSITE IMAGE of the Leonid meteor shower was created at Sandia National Laboratories on the night of November 18/19, 2003. More than sixty meteors were recorded that night through the new fish-eye lens installed just prior to the shower. SANDIA NATIONAL LABORATORIES

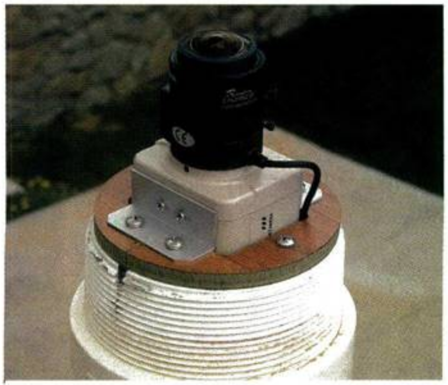
THE ALL-SKY FIREBALL NETWORK runs 24 hours a day. This daylight meteor was captured by a direct-viewing camera at Sandia National Laboratories. This event occurred on May 5, 2002, at 3:30 MDT and lasted several seconds. SANDIA NATIONAL LABORATORIES

THE JANUARY 11, 2003, FIREBALL, which reached magnitude −13.9, was captured by a direct-vision camera from Sandia National Laboratories. This fireball, which would have been visible in daylight, was imaged by several fireball network cameras. SANDIA NATIONAL LABORATORIES

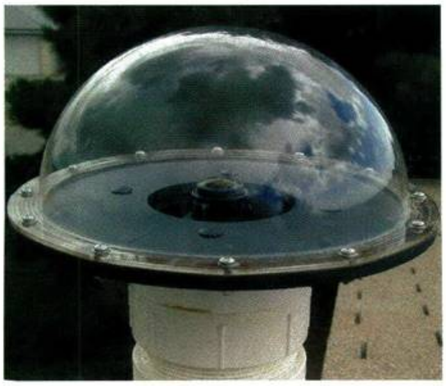
Joe Chavez, a Sandia Labs engineer associated with the satellite fireball observations, elected to complement the electrical engineering degree he received from Stanford with a master's degree in computer science. One step in completing the graduation requirements was to devise a project that applied computer science. Chavez proposed continually digitizing videos from all-sky cameras and examining them for fireball occurrences using a combination of custom-designed hardware and software. The faculty at New Mexico Institute of Technology accepted his proposal, and he then proceeded to design and program the system he dubbed *Meteor Sentinel*. Chavez's system was completed in 2001. Housed in an unassuming aluminum box, *Meteor Sentinel* has proved effective in recording fireball activity. In addition to automatic event capture,



ALL ORIGINAL MIRROR SYSTEMS, such as the one shown here, are being replaced by new, direct-vision fish-eye cameras. Here, a mirror camera is watched over by its nemesis — a bird. The long screws sticking up from the top cap are only partially effective in controlling a bird's desire to roost (among other things) on top of the camera. JIM GAMBLE



THE NEW FISH-EYE LENS is attached to the camera and mounted in its Poly Vinyl Chloride (PVC) housing. The camera's power adapter and video cable are inside the PVC tube totally protected from the weather. JIM GAMBLE



AN ACRYLIC DOME (in this case, 10 inches in diameter) sits on a base that houses the camera. A piece of weatherstripping serves as a gasket between the dome and the base, which are joined by twelve bolts and nuts. JIM GAMBLE

Sentinel includes other features that greatly facilitate both detection and event analysis. These features include: selective masking of areas containing nuisance false-alarm activity; automatic calculation of the center of fireballs encompassing multiple pixels (called the centroid); for radiometry, the summing of all fireball-related pixel values above a specified threshold for each scan; and precision time-tagging of video frames (when an accurate time reference is available).

A bright idea

For the videocamera systems in place at Sandia Labs, recordings on a separate, custom-built, all-sky radiometer (brightness meter) are available. These serve as a check for the accuracy of video-derived fireball magnitudes. Results show magnitude estimates made by researchers from the videotapes are in agreement with the radiometer. Calibration of the camera's light sensitivity is done by "shuttering" the camera off, then quickly on again during a Full Moon (which has a known visual magnitude of –12.7) using a piece of cardboard. *Meteor Sentinel* automatically locks onto the Moon, inputs the raw data into an *Excel* spreadsheet formula (also devised by Joe Chavez), and graphs the visual magnitude of a meteor event without an actual radiometer.

Where'd it go?

Meteor Sentinel's ability to calculate a fireball image centroid permits the tracking of the fireball's location in azimuth and elevation. Whatever the number of pixels employed in the camera, all video is converted by *Sentinel*'s digitizer chip to a 480x640 pixel format. If the entire 480 vertical pixels are used to display the 180° of sky from horizon to horizon, each of those pixels represents 0.375°. This would be about the limit for resolving the fireball's position if a phenomenon called blooming did not occur. Most fireballs saturate not only the pixel on which their image resides but many adjacent pixels as well (their image blooms), with some light also spilling over into surrounding, non-saturated pixels. Thus, dozens of pixels often have elevated values and are involved in

Jim Gamble *is a former meteorologist and a meteor watcher in El Paso, Texas.*

the centroid calculation. The result is that the location of the centroid generally can be determined to about a tenth of a pixel. In principle, this increases the accuracy of the precision of both the azimuth and elevation of a fireball to about 0.04°. This accuracy can be realized, particularly with cameras equipped with newly designed fish-eye lenses. In these systems, just a few precisely measured reference stars suffice to "calibrate" the entire field of view.

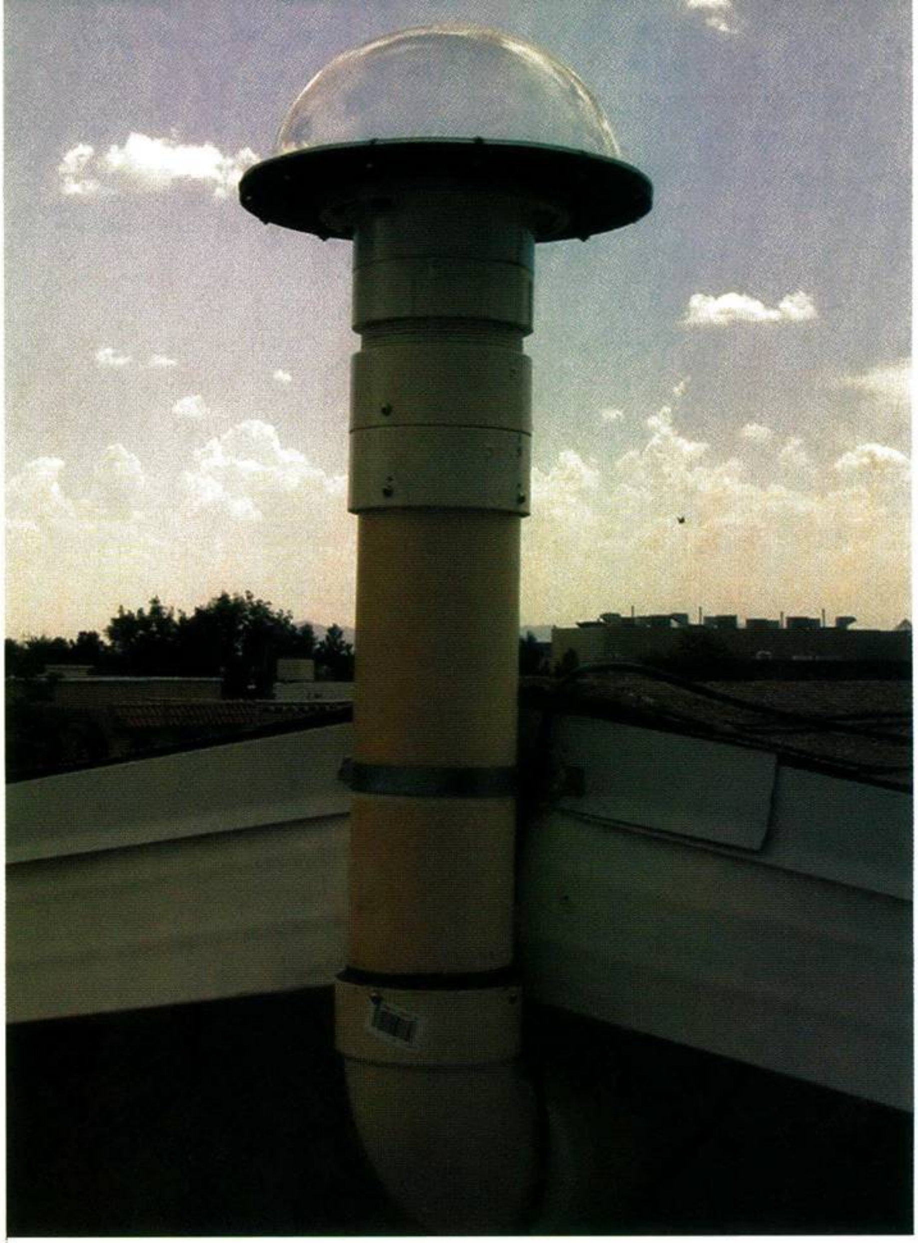
Nothin' fishy about fish-eyes

Fish-eye lenses have been around a while, but we are just beginning to realize the potential of these bug-eyed cameras for meteor detection. For one, they look directly at the sky, horizon to horizon, with no support struts or camera housing to obstruct recording a meteor's flight. These lenses are protected by an acrylic dome, which is much less susceptible to the "folly of fowl." When used with cameras employing newer, more sensitive CCD chips, stars brighter than 0 magnitude show up even without "stacking" images. By stacking video frames, whereby numerous frames are combined to make a single image, even fainter stars can be used for calibration of the camera's field of view. A big benefit of the fish-eye lens is there is virtually no elevation-angle distortion in the image. The lenses also are cheaper now than when the fireball network began. The Rainbow L163VDC4P lens, currently in use at many stations, costs about $150.

Dim and dimmer

Spending resources to detect and calculate dim, unspectacular events overhead may at first seem like a waste of time. But it also means we can see brighter events occurring farther from the camera. Fireballs recorded at Sandia are now routinely seen by El Paso and Las Cruces cameras 250 miles (400 kilometers) to the south. Plotting dimmer events also serves as calculation and procedural practice. Renowned meteor researchers around the world monitor Sandia fireball network data regularly. And if the past is any indication of the future, the Sandia Fireball Network could well become the preeminent meteor detection, imaging, and research network in the world. ◼

To join a discussion about all-sky photography, visit www.astronomy.com/toc



THE DOME AND SUPPORT TUBE that surround the fish-eye camera are attached to the house in a novel way. The tube is extended to allow all cabling to be run directly into the house. JIM GAMBLE

/// "HELLO, IS THIS WHERE I REPORT A BRIGHT STREAK IN THE SKY?"

When the operator of a fireball network camera receives a report of a bright fireball, the first line of investigation is to determine whether it truly was a meteor. Initial videotape analysis and confirmation from another camera location can help a fireball network member determine if it was a space rock, space program debris (a re-entering rocket, etc.), an aircraft, or even kids shooting fireworks. More careful analysis provides data such as altitudes and azimuths, length of flight in video frames, and an estimate of magnitude. Event video is then digitized and transferred to computer and forwarded to scientists at Sandia Labs for evaluation and verification.

With the new *Meteor Sentinel* automated software, fireball data can be calculated immediately and to a high degree of accuracy. In addition to elevation, azimuth, and magnitude calculations, a digital movie file and a composite image (all the movie frames of the flight combined into one image) are available immediately to the operator.

Plotting an event seen by two or more stations can quickly reveal beginning and ending altitudes, speed, angle of descent, and geographical location. All these data greatly aid researchers in locating the landing site in the event that fragments of meteoric origin make their way to the ground.

TECHNIQUES

If robotic-controlled telescopes are the future of astronomical observing, then Tenagra Observatories are leading this technological revolution. /// BY TOM POLAKIS

Robotic observing

Fifty million years ago, one star out of billions in an ordinary spiral galaxy ended its life in a spectacular blaze of glory. During several weeks, it grew to millions of times its usual brightness, briefly rivaling the combined light output of every star, nebula, and cluster in the galaxy. In 2003, that same star's light hit the mirror of a telescope in southern Arizona, was detected by the sensor of a CCD camera, and recorded on a computer while the owner of this equipment lay fast asleep.

In the mid-1990s, supernova hunting was the province of night owls who possessed the stamina to endure long, cold nights in the field. Now the tools of the trade are changing. Robotic telescopes enable astronomers to survey the sky more efficiently and reduce the data during the day. The result of this advancing technology has been an explosion in the number of supernovae detected. By 2002, more than half of the 2,433 supernovae in recorded history had been discovered in the previous six years. The future of astronomical discovery lies in the use of robotic equipment, and amateur astronomers like Michael Schwartz are leading the revolution in robotic-observation techniques.

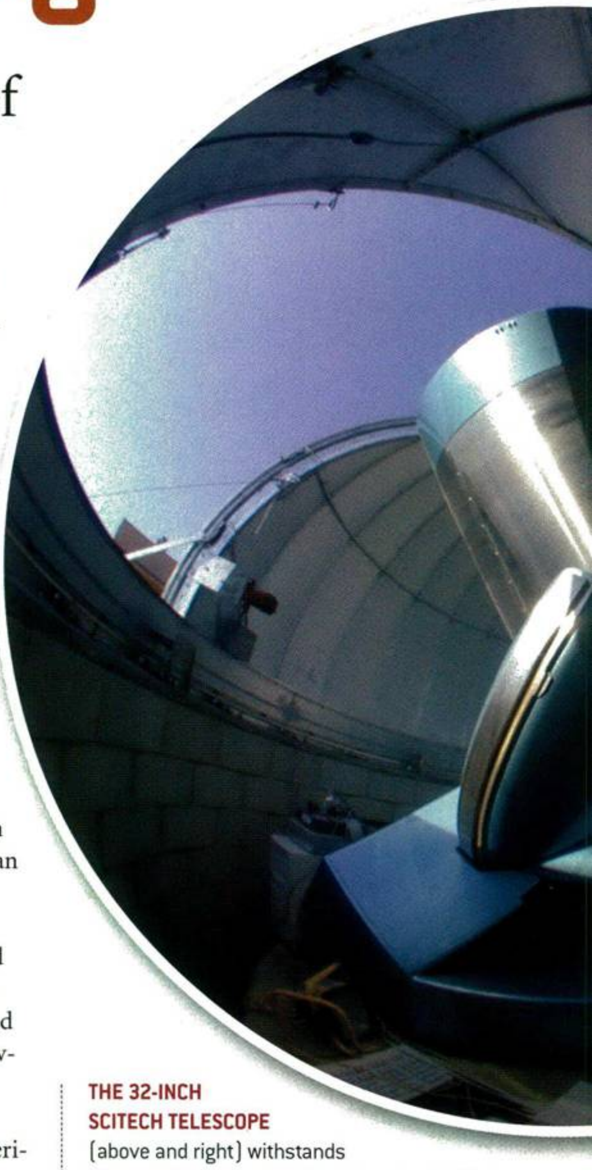
During an April evening in 2003, Schwartz's camera searches the star fields around 521 different galaxies for supernovae; this is a rather slow night, considering the camera often observes about 1,000. Just three of the 521 galaxies have made the cut, showing interlopers that have not been ruled out yet as minor planets or foreground stars. The previous night's image of one of these galaxies, NGC 4517, looks particularly promising, exhibiting an 18th-magnitude star near the core that doesn't appear in the archives. Schwartz suspects this one could be a supernova. He has discovered more than 40 of them since 1997, so when he says it looks promising, you believe him.

From dream to reality

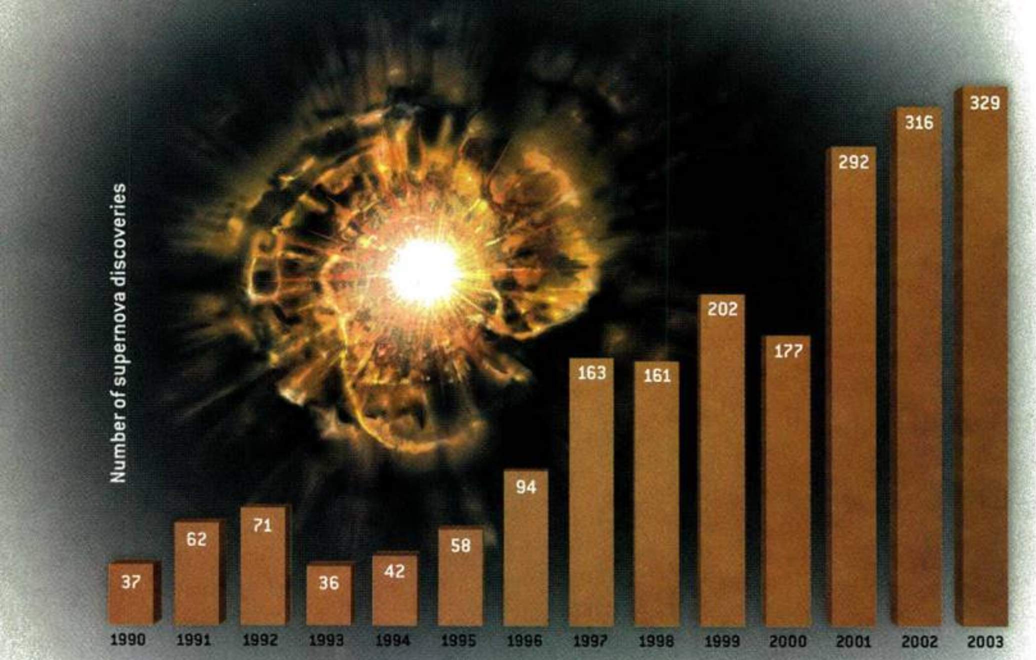
In 1997, Michael Schwartz left Prime Factors, Inc., the software company he founded in 1980, with enough capital to pursue his life's dream of hunting for supernovae. From a site in western Oregon, armed with a Celestron 14-inch Schmidt-Cassegrain scope and an Apogee AP7 CCD camera, he visually compared potential supernovae to star fields on the 102-CD set of the Digitized Sky Survey. In the first month of operation, he discovered three supernovae, and five more the next summer. These discoveries mark the beginning of Tenagra Observatories.

In 1999, Schwartz developed his superior Arizona site, relegating the Oregon observatory for use during the Southwest's summer monsoon months, between July 1 and September 15. The Arizona site is located in an ideal observing location in the Sonoran Desert, 4,300 feet above sea level. By no means as transparent as other world-class sites on other Arizona mountaintops, the seeing from Schwartz's Arizona site averages 2". Darker sites and steadier air exist, but logistics came into play during the planning stages of this project: How accessible was the site for installing equipment? Was Internet service available? Were power and water available? Would anyone want to live there?

Tom Polakis *lives in Arizona, where he is an aerospace engineer by day and a deep-sky observer and astrophotographer by night.*



THE 32-INCH SCITECH TELESCOPE (above and right) withstands Schwartz's rigorous nightly demands. Modified Ash domes work with the carefully orchestrated movements of each Tenagra telescope. Observing time on the 32-inch scope is available to professional astronomers; it is currently 30 percent subscribed. TOM POLAKIS



SUPERNOVA DISCOVERIES have increased significantly in just the last few years. This drastic increase of discovery relates directly to the growing practice of robotic observing. *ASTRONOMY*: ROEN KELLY

Two fully robotic telescopes stand on the Arizona property: a tenacious 32-inch Ritchey-Chrétien manufactured by SciTech Astronomical Research and a SciTech 24-inch Ritchey-Chrétien. A Celestron 14-inch telescope, a workhorse, sits on a Software Bisque Paramount.

Robotic observing challenges

Maintaining telescopic focus is no trivial matter. Components shrink as the air cools and deflect as the scope points to different altitudes. A pre-established model of these variables capable of corrupting data, in cooperation with an ongoing process of active focusing, ensures that precise focus is maintained throughout the night.

> Any wasted time in robotic observing is a mortal sin. — MICHAEL SCHWARTZ

Pointing and tracking, or "getting there and staying there," are equally important as focus. SciTech discarded the original gears of their mounts in favor of friction bearings with diameters measured in feet, which have an incredible pointing accuracy of 10". Exposures lasting up to five minutes require no guiding.

Schwartz uses off-the-shelf software that communicates with the Tenagra telescopes in a common language. This method differs from the approach of universities that often use incompatible "student-ware" unique to a particular telescope. Tenagra's software is used for telescope, dome, and camera control, image processing, and data reduction. Such familiar software names as *TheSky*, *MaxIm DL*, and *Astronomer's Control Panel* are installed on his machines.

Regardless of the money you're willing to spend, making a functional robotic survey observatory is hard labor. Carrying out hundreds of observations each night taxes all the equipment, from the computer software to the dome. During my stay, a dome resting on the ground rather than the walls of its observatory testified to the intense demands this type of survey work puts on hardware. Like other equipment that has occupied these grounds, this particular dome failed Schwartz's rigorous tests. This latest casualty pales in comparison to a 20-inch telescope that did not meet his specifications. Other equipment at the site purchased from reputable manufacturers has been coaxed into service only after extensive modifications.

Sharing the sky

But such trials and tribulations are worth it. The flawless functioning of the Tenagra telescopes has resulted in a successful collaboration with Lick Observatory to form the Lick Observatory Tenagra Observatory Supernova Search (LOTOSS). Lick defines observing lists, and the two parties double their productivity by sharing the sky rather than overlapping their searching areas.

Many of Tenagra's discoveries are scientifically significant. For example, bright galaxy NGC 2403 hosts a 19th-magnitude object that is not luminous enough to be a "true" supernova, so it's currently called a "luminous blue variable star" until astronomers invent a better name for it. In the same discovery frame as supernova 2003dt in NGC 6962 is the fading light of supernova 2002ha — two supernovae appearing simultaneously in one galaxy!

While Schwartz's passion is supernovae, his partner Paulo Holvorcem remotely controls the Arizona and Oregon scopes from his home in Brazil to monitor everything inside the radius of the Oort Cloud. His results — based on an average of one hour of observing per night — are staggering. In a recent eight-month period, the Tenagra telescopes recorded more than 7,000 asteroid observations, including 2,700 near-Earth objects (NEOs), and made 141 minor-planet discoveries.

Besides his many impressive observing contributions, Holvorcem also has authored various pieces of useful astronomy software that streamline the observing process at Tenagra. His *Tools for Automated Observing* performs the critical task of optimally scheduling robotic observations. The software determines the best path between targets to minimize idle time. "Any wasted time in robotic observing is a mortal sin," says Schwartz.

In addition to Holvorcem and Schwartz's observing time, Tenagra provides telescope time for professionals on a unique price structure. Typically, observatories charge per "observing run" — a block of time spent on the mountain — which usually lasts about a week. During that time, equipment and weather problems can limit the data acquired. Tenagra offers a fixed rate per hour of exposure, which allows for lengthy projects such as the nightly monitoring of a variable star for months at a time, or the determination of a rotation light-curve for an asteroid.

MICHAEL SCHWARTZ sits at "mission control" at the Arizona Tenagra site and reviews the past night's observations. Inset: Paulo Holvorcem (sitting) concentrates his and Tenagra's efforts on objects inside the Oort Cloud. A complement to Tenagra's advanced, user-friendly technology, Holvorcem conducts his observations remotely from his home in Brazil. TOM POLAKIS

Thrill of discovery

Schwartz does not consider supernova-hunting to be a competition. Instead, he enjoys the thrill of discovery and the desire to do it right. Other observers have excelled throughout the past decade due to similar enthusiastic persistence. Perhaps the best known is Tim Puckett, who conducts his searches from northern Georgia using homemade equipment. He has netted more than 60 discoveries since 1998.

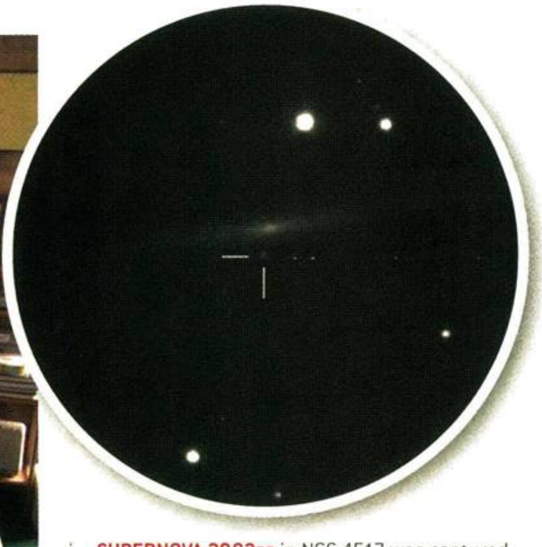
In Australia, Robert Evans, Schwartz's hero, has proven to be the greatest *visual* discoverer of supernovae. Every night, Evans visually surveys the star fields of hundreds of galaxies — whose star fields he has memorized. He made 37 discoveries between 1981 and 2002.

Yet the sky of the Southern Hemisphere remains largely untapped by robotic instruments. Schwartz is in the early stages of setting up a robotic observatory at a site in Australia. Schwartz intends to have four supernova survey telescopes and two wide-field instruments at his site in Australia — the first robotic setup in the Southern Hemisphere working to *his* exacting specifications.

The discovery of supernovae in large numbers isn't an aggrandizing game; rather, it has scientific merit. Most interesting are Type Ia supernovae, which result from the accretion of matter onto white dwarf stars. This class of supernova is an excellent standard candle — an object with predictable intrinsic brightness. If astronomers know how luminous an object is and how bright it appears, they can deduce its distance.

Recently, distances from Earth were computed for galaxies hosting Type Ia supernovae, and these results were compared to the traditional method of using redshift to determine distance. A systematic discrepancy in their distances indicates the universe has somehow accelerated from a "free coasting" state since the Big Bang. Increasing the sample size of supernovae enables astronomers to better characterize this phenomenon of the acceleration of the universe.

It is of great importance to capture supernovae during their early stages of development. Years ago, supernovae often were discovered only after they reached maximum brightness. This resulted in a well-characterized decay of the light curve, but little was known about the increase, which takes about three weeks from explosion to maximum light. Recently, more supernovae are captured during their rise thanks to galaxy surveys like LOTOSS. The rise-time reveals for astronomers the characteristics of progenitors of supernovae.



SUPERNOVA 2003DR in NGC 4517 was captured by Michael Schwartz. MICHAEL SCHWARTZ

Man vs. machine

The cloudy Arizona night in April passes without confirmation of Schwartz's prediction that the extra star in NGC 4517 actually is a supernova. However, from his site in northern Georgia, Tim Puckett discovers the same star and confirms it is a supernova. The newly discovered supernova is designated SN 2003dr on *IAU Circular* Number 8117. In the following weeks, the star does not brighten beyond magnitude 18. Only a handful of people observe the supernova, but this does not diminish its magnificence.

Schwartz reminisces about the last five years and muses over where his project will be in the next five. The upswing for robotic observing has just begun. Competition will lead to more reliable equipment to the point that a robotic telescope of modest aperture will be turnkey. Visual and manual discoveries still will be made, but non-human methods will dominate out of necessity. It is not only impractical for a person to do the observing, but it is also impossible to keep up with the rate of discovery that robotic scopes achieve.

All this dehumanizing of observing may seem to take the romance out of astronomy, but the thrill of discovery remains. Increasing knowledge is what all sciences are about, and it will take place by leaps and bounds in astronomy in coming years thanks to an unprecedented volume of data. The future of astronomical discovery has never held such promise. ■

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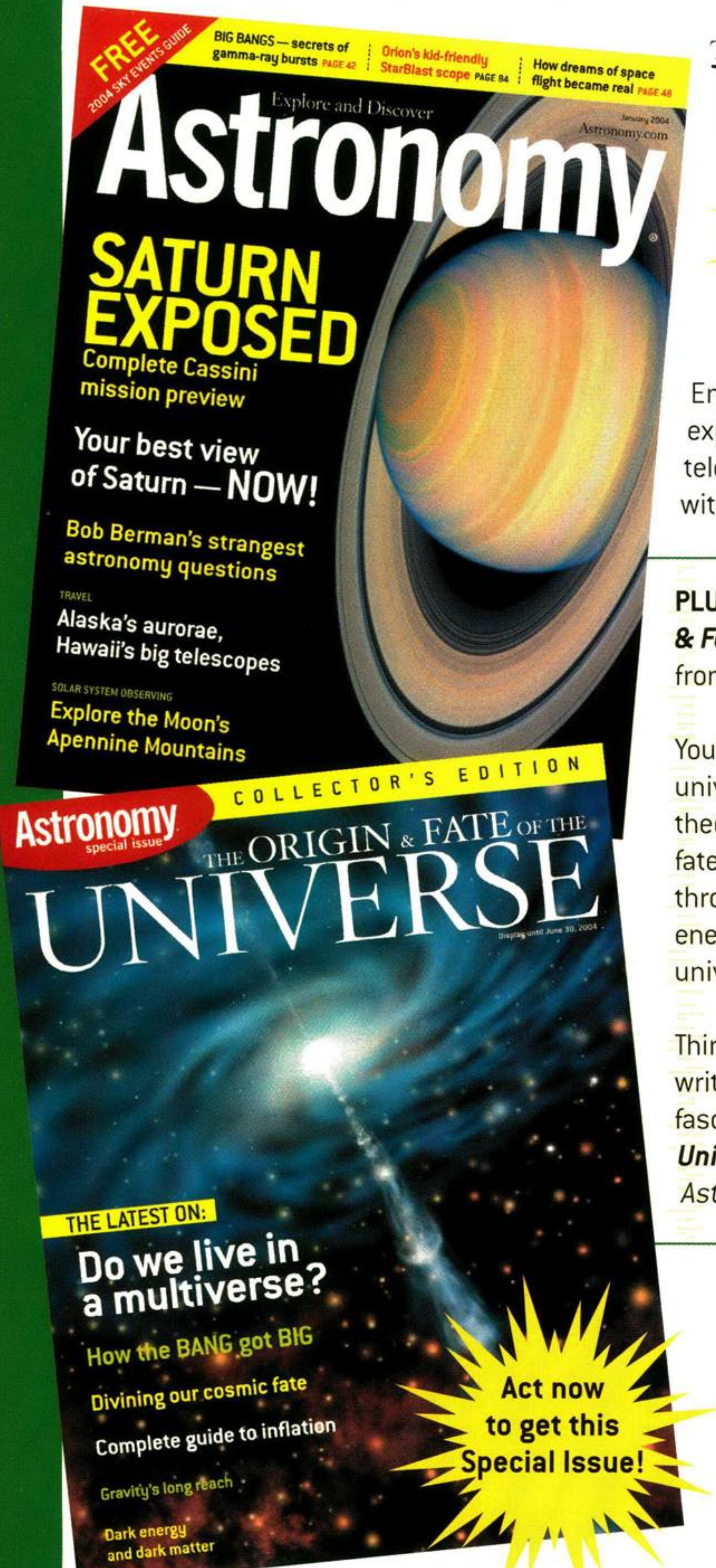

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Orion updated the traditional 8-inch reflector and made it perfect for the 21st century.

/// BY PHIL HARRINGTON

Orion's Atlas 8

Whether it's clothing, hair, or musical groups, styles come and go. What's "hot" today may be "not" tomorrow, only to be back in style next year. Although not as fickle as fashion, the telescope market also swings like a pendulum. In the 1960s, nearly every dedicated amateur astronomer owned either a 6-inch or 8-inch Newtonian reflector on a German equatorial mount. These instruments delivered high-quality views of sky objects both near and far.

Then along came the 1970s, and Newtonians fell out of style in favor of catadioptric telescopes. The 1970s faded into the 1980s, which brought "aperture fever" as the Dobsonian craze tempted amateurs with huge, double-digit-aperture Newtonian reflectors on basic wooden mounts. The 1990s saw catadioptrics sharing the market with refractors (themselves back from the 1960s) as well as Dobsonian-mounted Newtonians. But tried-and-true Newtonian reflectors on equatorial mounts were few and far between. Until recently.

Enter Atlas

Orion Telescopes and Binoculars has ventured "back to the future" with the introduction of their SkyView Pro and Atlas lines of Newtonian reflectors. The latest is the Orion Atlas 8, arguably the sturdiest equatorially mounted 8-inch Newtonian sold today. Like the equatorial Newtonians of yesteryear, the Atlas 8 can track the stars across the sky, letting the observer view targets for extended periods without having to nudge the telescope constantly.

But make no mistake — this isn't your parents' telescope! Unlike the German equatorial mounts of the 1960s, the Orion Atlas mount includes the latest innovations, including DC-powered, dual-axis stepper motors, a hand controller, and an illuminated polar-alignment scope. It does share one thing with those mounts of yesteryear, however: The Atlas 8 is massive, tilting the scales at 96 pounds. Fortunately, an intelligent design eases the burden of transporting the telescope.

PLÖSSL 25mm
PLÖSSL 10mm

THE 25MM AND 10MM EYEPIECES that come with the Atlas 8 yield magnifications of 40x and 100x, respectively. ASTRONOMY: WILLIAM ZUBACK

When you purchase the Orion Atlas 8, you're buying a complete telescope package ready for action right out of the box, thanks to a long list of included accessories: 10mm and 25mm Orion Sirius Plössl eyepieces, a 6x30 finder scope, a collimation eyecap, a camera adapter, and dust covers. All you'll need to add is a star atlas and a supply of D-size batteries.

Optics

The Atlas 8 telescope's steel tube assembly is built around an 8-inch f/4.9 primary mirror and a secondary mirror that measures 2.25 inches across its minor axis. Both are made of plate glass. Together, they create a fairly large (28 percent) central obstruction. Unfortunately, that's all but inevitable with such a fast focal ratio.

The primary lies in a mirror cell that is fully open in the back to allow rapid cooling. The cell also has four threaded holes for mounting a small muffin fan (such as Orion's part number 07814) to help speed mirror cooling. The secondary mirror is set in place on a four-vane spider mount. Both mirror mounts are easily adjusted.

The Atlas 8's focuser accepts both 2" and 1¼" eyepieces, the latter with an included adapter. Focusing is relatively smooth, although I suggest you replace the sticky grease used as a lubricant with something a bit lighter.

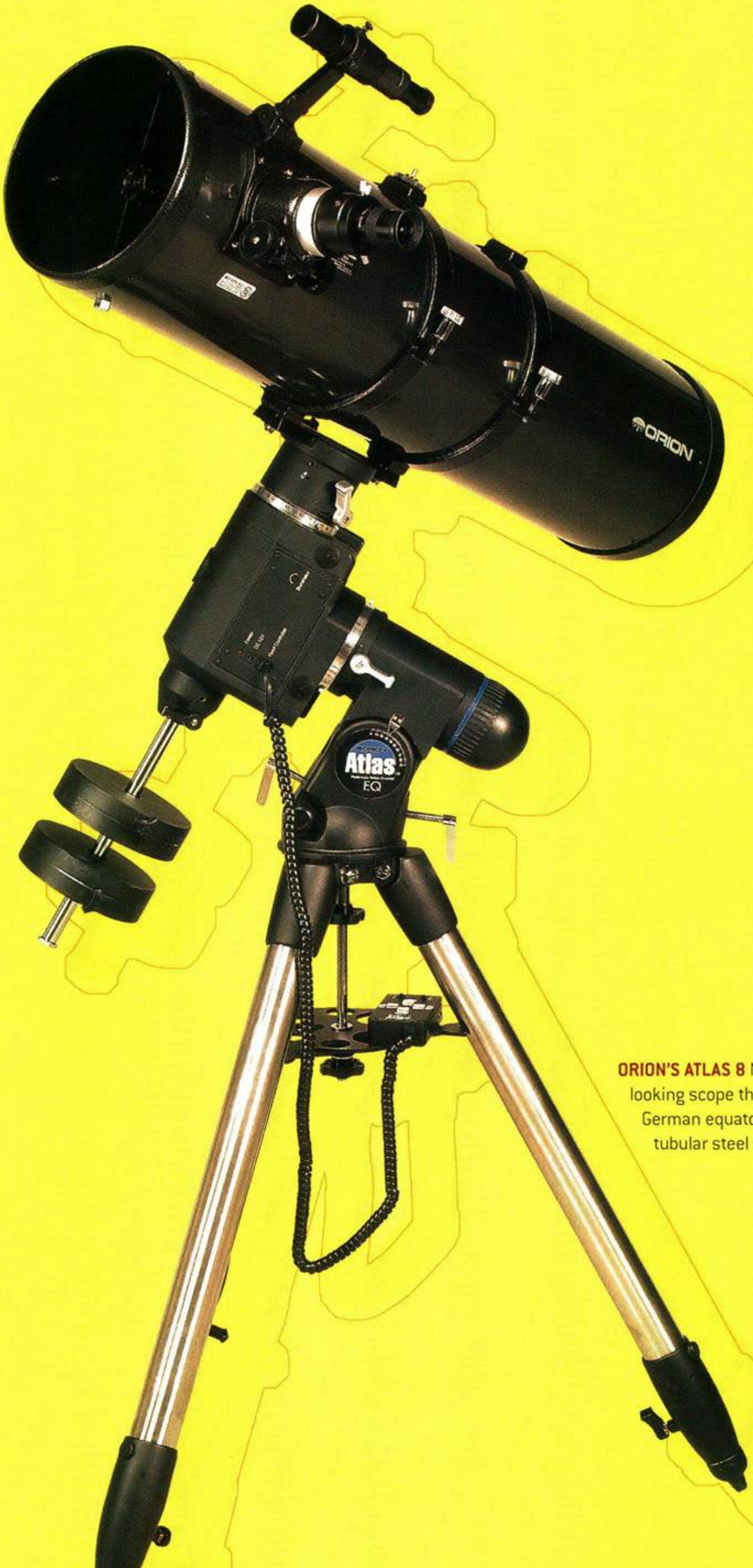
The Atlas focuser can be collimated, if needed. Three pairs of push-pull screws set around the focuser's base can be loosened to adjust the focuser's tilt. While this is a welcome feature, most purchasers would be best advised to leave well enough alone until they are fully confident with how to collimate the telescope's optics.

Mount and alignment

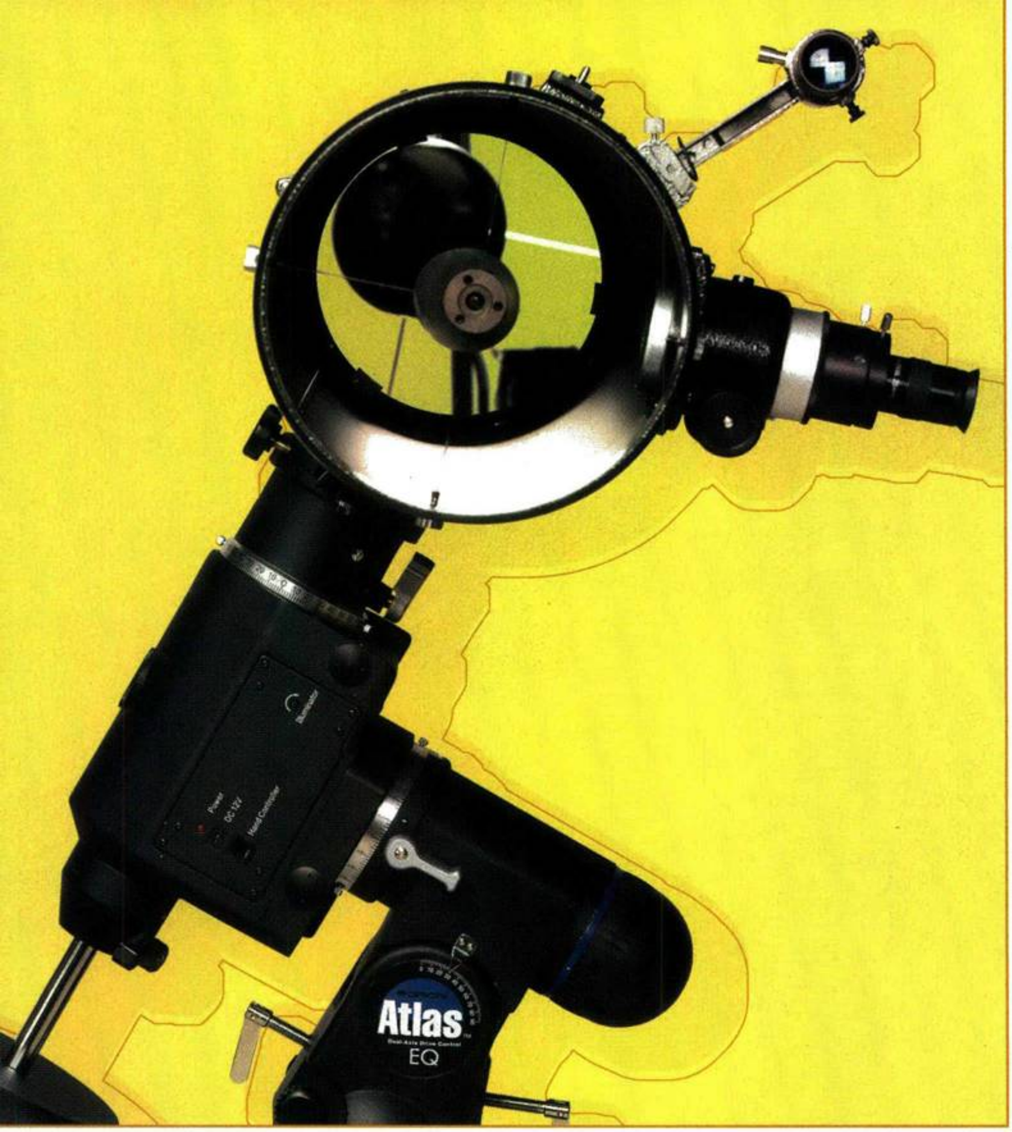
The Atlas mount is attractive, with a black powder-coat finish and fully internalized motors. A pair of large thumbscrews holds the telescope's rotating-ring dovetail assembly securely to the mount's saddle plate. The dovetail assembly can slide 6.5 inches fore and aft along the saddle plate for precise balancing.

If you're planning on doing guided astrophotography, then the telescope must be polar aligned accurately. To ease what can be a tedious job, the Atlas 8 mount

Phil Harrington *is the author of the new observing guidebook* Star Watch, *which is published by John Wiley & Sons.*



ORION'S ATLAS 8 Newtonian reflector is a great-looking scope that rides on a heavy-duty German equatorial mount supported by a tubular steel tripod. *ASTRONOMY*: WILLIAM ZUBACK



THE OPTICAL SYSTEM of Orion's Atlas 8 shows the f/4.9 primary mirror at the base of the tube and the secondary mirror supported near the top. *ASTRONOMY*: WILLIAM ZUBACK

includes a built-in polar-alignment scope. Turn on the illuminated reticle and look through the polar scope's eyepiece to see a slide showing the Big Dipper, Little Dipper, and Cassiopeia. Rotate the telescope around the polar axis until the stars on the slide are superimposed on the stars in the sky, and the North Celestial Pole should be aligned with the small cross in the slide's center. Because the alignment scope protrudes from the mount, always cover it with its threaded plastic cover when not in use.

Although I found the polar-alignment scope handy, adjusting its illumination level is a little tricky. The adjustment knob measures only about ⅛-inch in diameter and barely sticks out of the housing. The knob was difficult to turn with my fingers and impossible to grasp with gloves. A larger diameter knob would make adjustment both easier and more precise.

The beefy Atlas mount is also a solid performer. Motions are smooth in both right ascension and declination, even in temperatures below freezing. With the 20.5-pound tube assembly and two 11-pound counterweights, the mount remained reasonably steady in fairly strong wind gusts. Vibrations dampened in about 3 seconds after I rapped the side of the tube with the ball of my hand.

The dual-axis drive tracked the sky accurately with no jumping or vibrating from the stepper motors, even when observing at 356x. The hand controller's right ascension and declination responses are immediate, with the telescope starting and stopping the instant a button is pressed or released. I saw no evidence of backlash or dead spots in either drive axis.

If I had to offer Orion one piece of advice regarding the Atlas 8, it would be to fit the telescope with a larger finder scope. The 6x30 that comes with it is inadequate for serious star-hopping. I advise buyers to purchase either an 8x50 or 9x50 instead. The finder scope's dovetailed base on the Atlas 8 will accept finder mounts sold by Orion and several other companies.

Power and drives

Power for the polar reticle as well as for the dual-axis drive motors comes from either a 12-volt DC source or from a 110-volt AC source (with a converter sold separately). Owners also can choose to power their telescope with a rechargeable cell or car battery. Eight D-cell batteries (using the included battery holder) powered the test telescope. Orion reports a set of batteries should let the scope track for about 60 hours, but my alkaline batteries powered the drive for more than 84 hours. Your numbers may vary, and lots of slewing certainly will shorten battery life.

Pressing buttons on the hand controller sets the speed of the drive's stepper motors. Slewing can coast along at either 8x or 16x the tracking rate, while fine-guiding for astrophotos is set at 2x the tracking rate. Don't confuse this telescope's tracking with the automated go-to motions of other telescopes. The Atlas 8 has neither a computer nor digital setting circles. It relies entirely on the user to move it around the sky by hand.

The Atlas's tripod is a sturdy unit built on three 2-inch-diameter stainless steel legs. Each two-part leg extends between 33 and 58 inches in length using a quick-release clamp. A spreader, which includes a tray to hold three 1¼" eyepieces and three 2" eyepieces, screws into the underside of the mounting head and presses outward against the three legs to improve the mount's overall rigidity.

Collimation and testing

Orion ships the Atlas 8 in three well-padded boxes: one for the tube assembly, a second with the German equatorial mount, and a third containing the tripod. The instrument needed collimation on arrival. I collimated the Atlas 8 using Orion's combination sight tube/Cheshire eyepiece tool (sold separately).

With the telescope set up and collimated, I set out to check optical quality by conducting a *star test*. Results proved the Atlas 8 has excellent mirrors. The star test showed optical quality exceeded ¼-wave.

Studying an out-of-focus star through a Ronchi tester confirmed the high optical quality. Images showed only a slight bowing of the outer test lines, indicating an inconsequential trace of spherical aberration. Subsequent viewing proved these test results to be true, as images were sharp.

With optical testing complete, I began my tour of the winter sky with the Orion Nebula (M42). The 52° apparent field of view of the 25mm eyepiece translates to a real field of view of just over 80', more than enough to fit the entire sword of Orion. With M42 centered, the subtle glow of the reflection nebula NGC 1975 was faintly visible along the northern edge of the field, while Iota (ι) Orionis, the sword's brightest star, was clearly visible to the south. Switching to the supplied 10mm eyepiece, the Trapezium easily resolved into four sharp points of bluish-white light. All views were memorable.

My tour of the winter sky continued with stops at open clusters M36, M37, and M38 in Auriga, as well as M35 in Gemini, one of my favorites. The 25mm Plössl proved ideal for viewing these objects.

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Atlas
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THE HAND CONTROLLER for the Atlas 8 allows two slewing speeds, 8x and 16x the tracking rate, and a guiding speed 2x the tracking rate.

ASTRONOMY: WILLIAM ZUBACK

The Pleiades is often cited as one of the sky's finest star clusters for binoculars but not for telescopes due to their narrower field of view. The short focal length of the Atlas 8, however, means all seven sisters, as well as a crowd of stellar cousins, can squeeze into the 25mm eyepiece's field. The stars sparkled brilliantly but also revealed one of the down sides of a fast astronomical telescope: coma. The stars along the edge of the field were noticeably distended into tiny, comet-shaped blurs.

Orion's ads state the 39.2-inch (996mm) focal length and 4.9 focal ratio mean the Atlas 8 is ideally proportioned for wide-field views of large deep-sky objects such as the Orion Nebula and the Andromeda Galaxy (M31). While this is true, don't take it to mean the Atlas 8 won't deliver good views of small-scale objects too. Even when I boosted the magnification to 356x (using my 7mm Pentax XL eyepiece and 2.5x Tele Vue Powermate), the Atlas 8 provided a good view of Saturn's subtle equatorial banding, the Cassini Division, and C ring, as well as details in Jupiter's multi-colored atmosphere. Further, when it was turned toward some winter double stars, the Atlas 8 easily resolved Castor, Rigel, and several other pairings separated by only 1.5". Local seeing conditions prevented me from splitting closer pairs.

Beyond visual use

Although my test of the Atlas 8 was primarily as a visual instrument, Orion touts its astrophotographic abilities as well. The universal camera adapter that comes with the telescope makes it possible to couple just about any digital or 35mm single-lens reflex camera directly to the focuser once you marry it to a camera-specific T-adapter, available at most camera stores.

Regarding the drive, slight tracking errors always are present in a clock drive's gear system. These so-called periodic errors occur with precise regularity, usually keeping time with the rotation of the drive's worm gear. Some high-end telescope mounts include periodic-error correction (PEC) circuits that eliminate the need for users to correct these errors themselves. The Atlas 8 doesn't have a PEC circuit, but Orion sells an astrophotographic package that includes an 80mm refractor, 5mm illuminated reticle eyepiece, and mounting rings.

/// ATLAS 8 SPECIFICATIONS

Optical system:
8-inch f/4.9 Newtonian reflector

Mount:
German equatorial on adjustable tripod

Accessories:

- 6x30 finder scope
- Rack-and-pinion focuser (accepts 1¼" and 2" eyepieces)
- Illuminated polar-alignment scope
- Dual-axis DC-powered clock drive with hand controller
- 10mm and 25mm Plössl eyepieces
- Camera adapter
- Collimation cap
- Dust caps

Weight:

- Optical tube assembly: 20.5 pounds
- Equatorial head: 37.5 pounds
- Counterweights: 11 pounds each (two supplied)
- Tripod: 16 pounds

Price: $1,099

Contact information:
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If you're looking for a lightweight instrument, the Atlas 8 isn't for you. No denying it, the Atlas mount takes quite a bit of effort to carry. And if you happen to be a gadget junky looking for computerized bells and whistles, this is not your telescope either. Better stick with other instruments that divide their strengths between optics and electronics.

But if you're looking for a telescope for visual observing that also will let you dabble in wide-field, guided astrophotography, then the Orion Atlas 8 should be on your short list of choices. Its impressive optical quality combined with the mechanical stability of its equatorial mount and the attractive price all make the Orion Atlas 8 a great instrument that will never go out of style.

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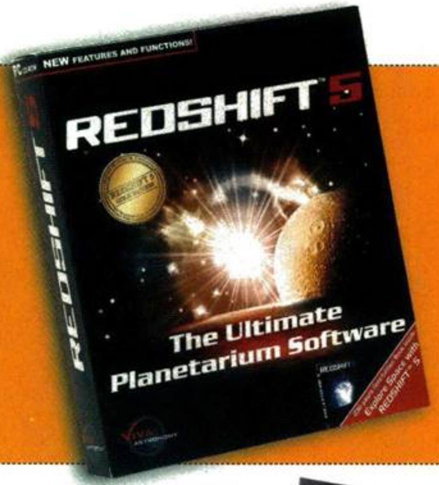
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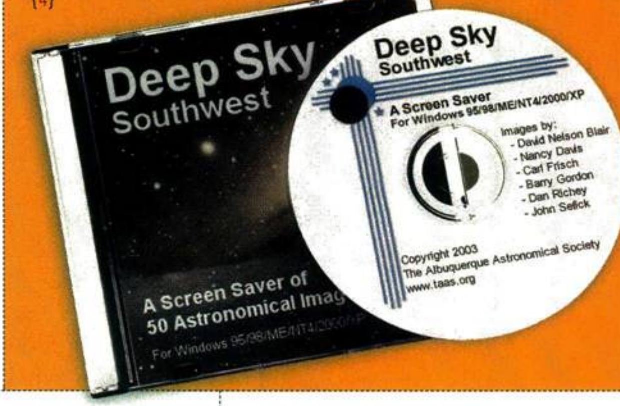
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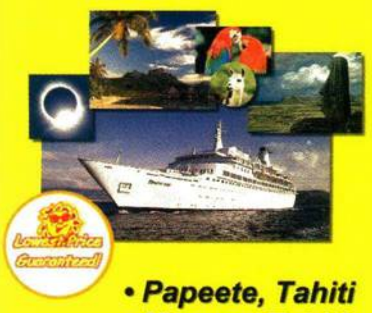

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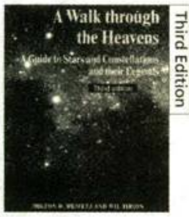

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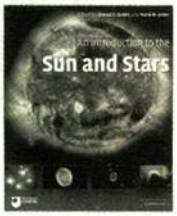

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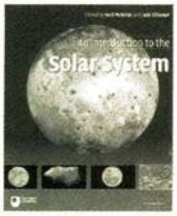

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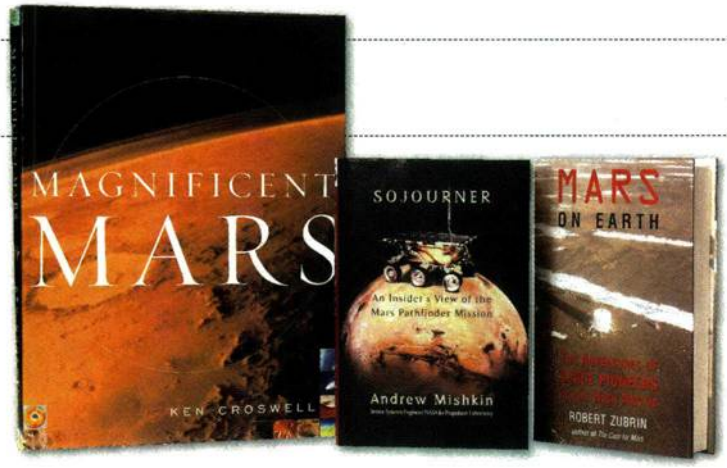
Three trips to Mars



Magnificent Mars

Ken Croswell, 210 pages, Free Press, New York, 2003; ISBN 0-7432-2601-1; hardcover, $60.

We have invaded Mars. A fleet of alien spaceships — NASA's Mars Global Surveyor and Mars Odyssey and the European Mars Express — is now orbiting the Red Planet. Two rovers, Spirit and Opportunity, recently bounced onto the martian surface and are rolling across it.

Ken Croswell's coffee-table-format book, *Magnificent Mars,* makes a stunning introduction to the Red Planet. Croswell is an engaging writer, conveying facts and stories in clear and interesting language. The book's design is also striking, with typically a full-page photo facing white text on a black page.

Magnificent Mars starts with an historical overview, followed by four sections, Earth, Air, Fire, and Water, that deal with geology, atmosphere, volcanism, and water (including possibilities for life). After a section on the moons Phobos and Deimos, the book ends with five large, colorful tables about Mars and missions to it.

Aimed at beginners, the text includes science results from the Mars Global Surveyor and Mars Odyssey missions. For example, the Fire section contains about ten pages highlighted by the discovery that andesite — a moderately silica-rich type of volcanic rock — appears to be common on Mars in addition to the expected basalt, and that Mars's tallest volcano, Olympus Mons, is really only 21.287 kilometers high, not 26 km as previously thought.

This is a picture book and some of the images, in their nearly 11" by 14" format, are glorious, especially a series of globes with boldly colored topography. Other photos, blown up to large size, are pixilated and grainy. Nonetheless, this is an impressive book for any Mars fan.

— **CHARLES WOOD** *is a planetary scientist with an interest in volcanic processes.*

Sojourner: An Insider's View of the Mars Pathfinder Mission

Andrew Mishkin, 319 pages, Berkley Books, New York, 2003; ISBN 0-425-19199-0; hardcover, $21.95.

I once explained to a colleague that the view from the Sojourner rover was about what you get lying on your stomach: "Just imagine that you are crawling around Mars on your belly, and your eyes are about 10 inches off the ground. It's a good way to see dirt and small rocks, but you don't get an overall view."

Andy Mishkin's book is very much a "rover's eye view" of Mars exploration. It's not about Mars or 1997's Mars Pathfinder mission — it's about the joys and frustrations of building hardware to operate on another planet. He ought to know: He led the development of the Sojourner rover.

Little Sojourner struck a chord with the public, and the story of how it came into being is interesting. The book is at its best telling that story. Andy is a talented writer who makes a technical story come alive by explaining complex things simply. And the tale has plenty of drama.

The process of building anything to fly in space is a battle with tough engineering, not enough time or money, the cussedness of inanimate objects, and the delusions of your own bosses. It is a process of design, build, test, break, fix, test again, break again, fix differently, test more, fix more, and slide in under the deadline. The rollercoaster of challenges and emotions in this process are captured in the book.

However, it is possible to have too much of a good thing. Clever problem solving, lightly and briefly treated, is engaging, but if repeated too often, it becomes mind-numbing. There are about 50 pages too many of sentences like: "The only way for the deployment mechanism to move in just one direction was if there had been a FET failure of the H-bridge circuit controlling the ADM motor."

Also, paranoia is not an engaging literary device. Andy presents Sojourner's development as a battle between a talented and dedicated "Us" (the Sojourner core team) and a sometimes malicious "Them" (higher management, other engineering groups, Ph.D. engineers, scientists, the Pathfinder Lander team).

As a scientist on the Pathfinder Imaging Team, I was one of Them. I know from my own experience that many members of the rover team did not share Andy's Us/Them attitude. I was particularly bothered by the treatment of individuals with whom Andy disagreed. A book chronicling a singular achievement is not the place to detail the character flaws of your coworkers and colleagues. If nothing else, it detracts from the story's focus. And, curiously, the book covers only perfunctorily the process of roving on Mars — it occupies just 23 pages of 319.

In sum, this book is a very personal view, by a talented and skilled writer, of the technical and emotional rollercoaster that is space exploration. Like any personal view, it is limited in scope to what the author experienced. That experience, however, is what many of us dream about as children: exploring other worlds, landing in alien places, building spaceships. By any standard, that makes a hell of a story.

— **DAN BRITT** *teaches planetary science at the University of Central Florida when he isn't visiting Mars by proxy.*

Mars on Earth

Robert Zubrin, 352 pages, Tarcher/Penguin, New York, 2003; ISBN 1–58542–255–X; hardcover, $28.95.

Since the summer of 2000, a new phenomenon has been taking place in barren, windswept corners of Earth. A series of arctic and desert tests — documented in Robert Zubrin's new book — mimic martian exploration. In lieu of satellites or robotic rovers, however, the trials simulate human explorers afoot on the Red Planet.

Volunteers from the privately funded Mars Society — a collection of scientists, engineers, and space enthusiasts promoting manned Mars missions — spend one to three weeks living in tuna can-shaped habitats in remote locations. One of these, the focus for the book, is at Houghton Crater on Devon Island in Canada's arctic.

Donning clear plastic helmets, canvas jumpsuits, and black army boots as spacesuit simulators, the habitat crews make forays into the field on ATVs. They visit outcrops, take rock samples, and analyze them back at the habitat. The goal is to carry out geological and biological field work without "breaking sim" — that is, taking off a helmet or otherwise doing something that would kill you on Mars.

This is the current culmination of astronautical engineer Robert Zubrin's ongoing crusade to send humans to Mars. His book documents events from the creation of the Mars Society to the planning, construction, and operation of the first Earth-based station at Houghton Crater.

The book's extraordinary level of detail can be as compelling as a space-based reality TV show. A self-portrait of Zubrin emerges as an energetic dynamo of a commander for whom "failure is not an option." But there's also a downside: Zubrin can come across as volatile and seemingly as hungry for glory as for scientific knowledge. During station squabbles, he rails against malcontents, quitters, and "a bunch of chickens."

More seriously, sweeping statements are presented as scientific fact. Bacteria, he says, "almost certainly did" exist on Mars and have "without question" journeyed between the planets. Maybe, maybe not.

Zubrin's recommendations for choosing a Mars crew are flimsy to the point of being laughable. We should "exercise due caution in departing from" an all-male model, he says. Why? It has been the tradition of exploration "for the last 40,000 years, [so] people are most comfortable with it." He also cautions against picking a woman or young man as commander.

Although Zubrin bases conclusions more on personal conviction than scientific data, he is a meticulous diarist and historian for the humans-to-Mars effort.

— **JESSA FORTE NETTING** *writes about astronomy and biology from a windswept corner of Brooklyn, New York.* ■

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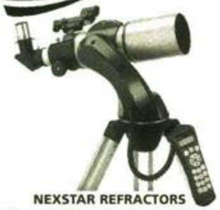

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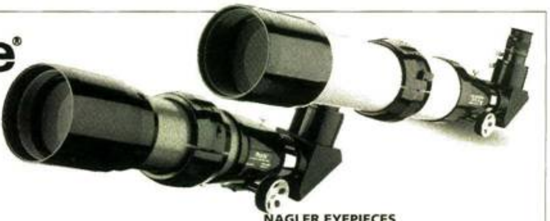

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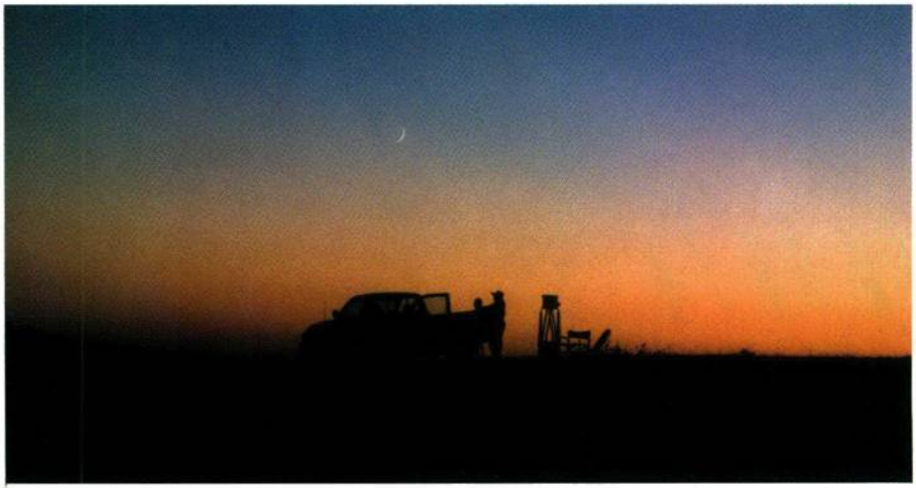

A SLIM CRESCENT MOON appears at sunset as two attendees at the Nebraska Star Party prepare their equipment for a night of observing. MARK DAHMKE

In addition to observing, scheduled activities include workshops, an ice cream social, a beach party, contests, canoe and tubing trips down the Niobrara River, a beginner's field school of astronomy, and numerous educational activities for children. Catered meals will be provided.

For more information, e-mail Doug Bell at dougbell@navix.net; web site, www.nebraskastarparty.org.

04.24.04

AstroDay

Prince Kuhio Plaza, Hilo, Hawaii. If this third annual event is like its predecessors, thousands of people will pack Prince Hilo Plaza to view astronomical displays and participate in workshops. For more information, e-mail Gary Fujihara at fujimon@mac.com.

05.04.04

Far Out Friday

Adler Planetarium, Chicago. On the first Friday of every month, the Adler hosts an evening of observing and education. Experts will be on hand to answer questions and help visitors with using a telescope. For more information, visit www.adlerplanetarium.org.

05.14.04–05.16.04

Northern Arizona Star Party

Prescott National Forest, near Dewey, Arizona. There will be several drawings for prizes at this star party. The site is very rustic — there are no electrical hook-ups. For more information, contact Richard Leon at 928.772.2505; e-mail, richlin76@commspeed.net; web site, www.pacorg.net.

05.21.04–05.23.04

Georgia Sky View

Camp McIntosh, Indiana Springs State

Park, near Jackson, Georgia. Hosted by the Flint River Astronomy Club, this is a popular observing weekend for southern stargazers. For more information, visit www.flintriverastronomy.org.

05.21.04–05.23.04

SkyTour

Near Monroeville, Ohio. The Huron Valley Astronomers Group and Tech2000 sponsor this laid-back star party. Attendees will be able to board the NASA-GLENN bus, a space education vehicle. For more information, call 419.465.2997; web site, homepages.accnorwalk.com/tddi/tech2000/skytour.

06.14.04–06.20.04

Laurel Highlands Star Party

Pine Hill Campground, Hazelton, West Virginia. This four-day event features guest speakers, extended children's activities, a model rocket launch, vendors, a swap table, door prizes, and catered food. For more information, e-mail jmholtz@aol.com; web site, www.lhstarcruise.org.

06.18.04–06.19.04

Shingletown Star Party

Shingletown Airport, Shingletown, California. Each year, seasoned veterans and novices of astronomy gather on the Shingletown Airport's runway for observing. As with similar events, attendees will also find lectures, workshops, and vendors at this star party. For more information, visit www.shingletownstarparty.org.

07.13.04–07.19.04

The Mountain Institute Summer Astronomy Camp

The Spruce Knob Mountain Center, near Franklin, West Virginia. For 7th through 12th graders, this week-long camp affords youngsters an opportunity to see the stars from a high altitude and to visit the National Radio Astronomy Observatory. Activities during the day will include natural and astronomical studies. For more information, visit www.mountain.org/skmc/index.html.

07.17.04–07.20.04

Lowell Observatory Star Party

Lowell Observatory, Flagstaff, Arizona. Highlights of this second annual gathering include observing with the Clark Telescope, lectures, observatory tours, and vendors. Discussion topics include the latest from the Mars Rovers, recent comets, asteroids, and a preview of the $30 million Discovery Channel Telescope. For more information, visit kraken.lowell.edu.

07.17.04–07.20.04

Wisconsin Observers' Weekend

Hartman Creek State Park, Waupaca, Wisconsin. Hosted by Northeast Wisconsin Stargazers, this event features three nights of family fun and observing. For more information, visit www.new-star.org.

07.20.04–07.24.04

AstroCon

Mills College, Oakland, California. This gathering will bring together important organizations that surround, serve, and support amateur astronomers, such as the Astronomical Society of the Pacific and the Association of Lunar and Planetary Observers. The agenda will include paper presentations, workshops, and field trips. For more information, visit www.astrocon2004.org.

08.01.04–08.21.04

International Astronomical Youth Camp

Jugendherberge Aschberg, Klingenthal, Germany. This camp is a three-week program for English-speaking students ages 16 to 24 who are interested in astronomy. For more information, visit www.iayc.org. ■

CONTACT INFORMATION

Please submit club announcements four months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Add your events to our on-line calendar at www.astronomy.com.

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RESOURCES

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GREAT COMETS

BOOKS — For a detailed look at comets of the past, check out Gary Kronk's *Cometography* (Cambridge University Press, New York, vol. 1, 1999; vol. 2, 2004). Two volumes have appeared so far out of a projected four. The first volume covers ancient times through 1799, while the second covers 1800–1899. In addition to when and where a comet was discovered, Kronk tells how long it remained visible as well as many other details. Donald Yeomans's *Comets* (John Wiley & Sons, New York, 1991) likewise gives a chronological history of observations, science, and myth.

Carl Sagan and Ann Druyan's *Comets* (Random House, New York, 1985) was published when Comet Halley returned as a naked-eye object in the mid-1980s. The book was reissued in paperback in 1997 for Hale-Bopp's apparition. The first edition is the one to look for — it contains lots of colorful images of great comets omitted from the later edition. Another book with lots of photos, especially of comets Hyakutake and Hale-Bopp, is Robert Burnham's *Great Comets* (Cambridge University Press, New York, 2000).

WEB — The Jet Propulsion Laboratory (JPL) has two excellent web sites devoted to great comets Hale-Bopp and Hyakutake. Both appeared shortly after the World Wide Web became well known to the general public, so these two are, in effect, the first "great Internet comets." For Hale-Bopp, go to *www2.jpl.nasa.gov/comet/*, and for Hyakutake, *www2.jpl.nasa.gov/comet/hyakutake/*. Both sites archive images (more than 5,000 in the case of Hale-Bopp) and news releases, although some links to stories outside JPL have not been updated and are defunct. They also provide links to other comet-oriented sites.

DESTINATION: MARS

BOOKS — Find out about the United States's past missions to the Red Planet in *Mars: The NASA Mission Reports* (Robert Godwin, ed., Apogee Books, Burlington, Ontario, Canada, 2000). This book is the ultimate collection of official press releases, data, and diagrams from the space agency. Beginning with 1965's Mariner 4 and continuing through 1999's Mars Polar Lander, material is presented chronologically, providing the serious reader a detailed look at how technology and science objectives have changed over time. The book also includes a CD-ROM with images and movies, making it a one-stop reference for mission plans and spacecraft specifications, among other things. Be sure to look for Volume 2, which was released by Apogee Books in February 2004.

ARTICLE — For an in-depth report on the rover Spirit's search for water in the martian soil, see "Spirit lands at Gusev" by Bruce Moomaw (*Astronomy,* April 2004).

WEB — Explore NASA's site for both Spirit and Opportunity at *marsrovers.jpl.nasa.gov/home/index.html*. Look for news updates on the rovers' progress from Steve Squyres, a Cornell University scientist and principal investigator for both rovers, at *athena.cornell.edu*. This site also includes mission animations, a "Mars for Kids" area, and wallpaper for your computer.

To learn about other current and future U.S. missions to Mars, check out JPL's site at *marsprogram.jpl.nasa.gov/missions*.

Attempts to explore the Red Planet have had mixed results for all nations. For a complete time line of missions — successes as well as failures — see "Journeying to Mars" by Matt Quandt at *www.astronomy.com/Content/Dynamic/Articles/000/000/001/362soqxn.asp*.

A NEW VISION FOR SPACE

ARTICLES — *Astronomy* has published a number of articles on space exploration recently. In "Harvest the Moon" (June 2003), planetary scientist Paul Spudis argues the many benefits of a return trip to the Moon. "Blazing a new path" (August 2003) by the lead Mars Exploration Rovers (MER) science team member Jim Bell is a comprehensive overview of the MER mission, including the objectives and rationale for the current missions. And Bob Berman's "Trial by fire" (July 2003) recounts the tragedies and explores the danger of space flight.

In "Journeys into the new millennium" (*Astronomy*'s special issue *Explore the Universe 2004*), John Shibley outlines the missions different space agencies (NASA, the European Space Agency, and Japan's Institute of Space and Aeronautical Science) have planned for the next decade.

WEB — A transcript of President Bush's speech given at NASA headquarters on January 14, 2004, in which he outlined his vision for space exploration is at *history.nasa.gov/Bush%20SEP.htm.*

A TALE OF TWO COMETS

WEB — The web has two excellent sites for comet observers. The first, maintained by article author Charles S. Morris, is the Comet Observation Home Page at *encke.jpl.nasa.gov*. With the latest comet news, observations, and photographs, as well as detailed archives of past comets, this site is a great place to visit to keep up with the progress of comets C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR).

Seiichi Yoshida's home page at *aerith.net/#Astronomy* includes finder charts and light-curves for most comets within range of typical backyard telescopes. A nice feature of this site is a listing of future visual comets, including expected magnitudes as well as whether the comets are visible from the Northern or Southern Hemisphere and at what time of night.

ROBOTIC OBSERVING

WEB — To learn more about the trend of robotic observing, visit *www.tenagra observatories.com*. While you're there, sign up for observing time on the 32-inch telescope and test drive this cutting-edge technology for yourself.

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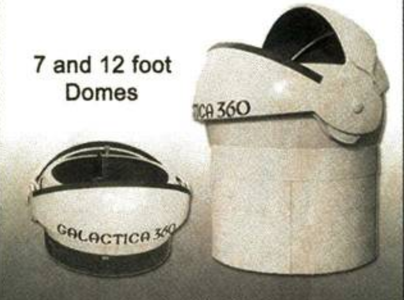

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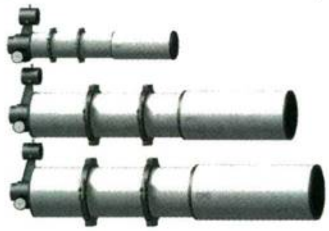

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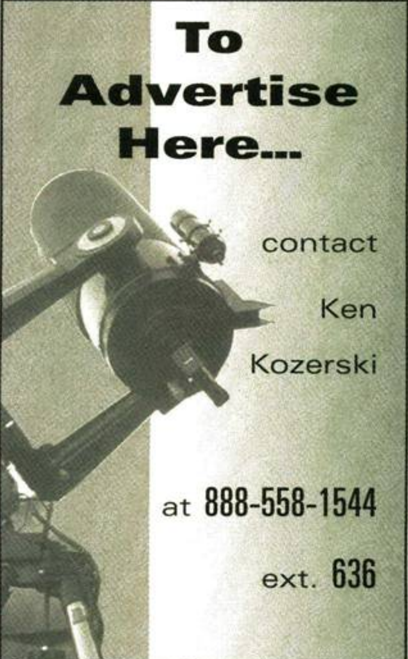

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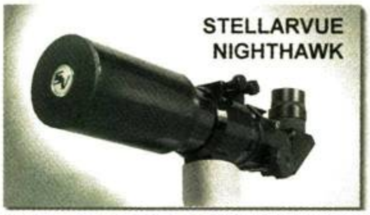

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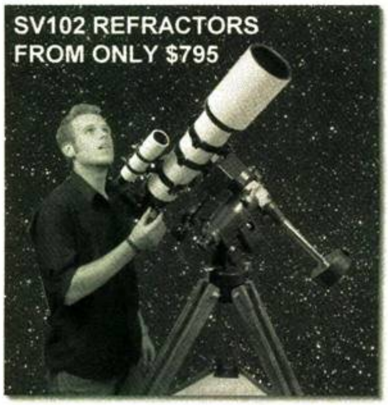

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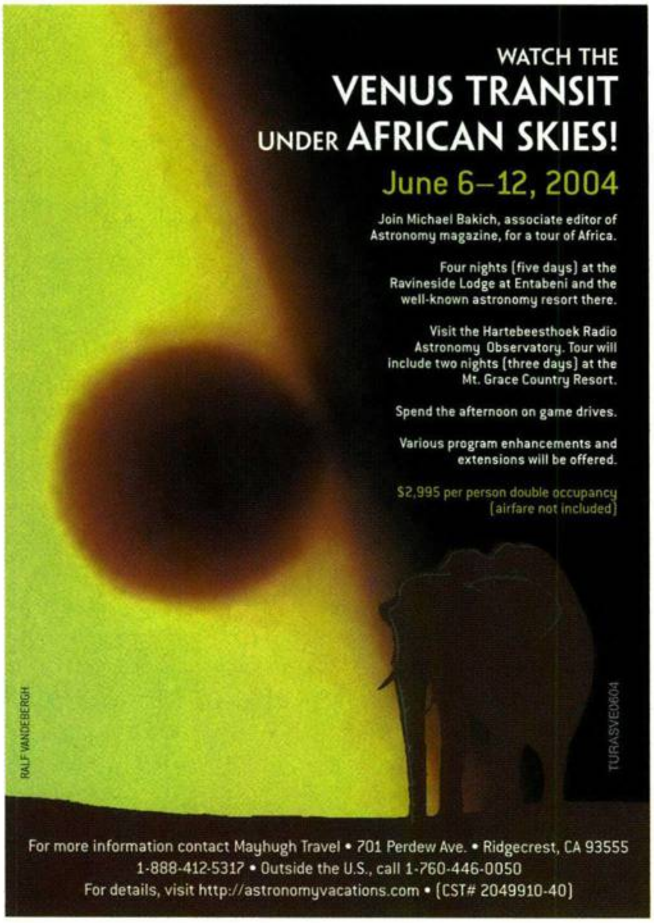

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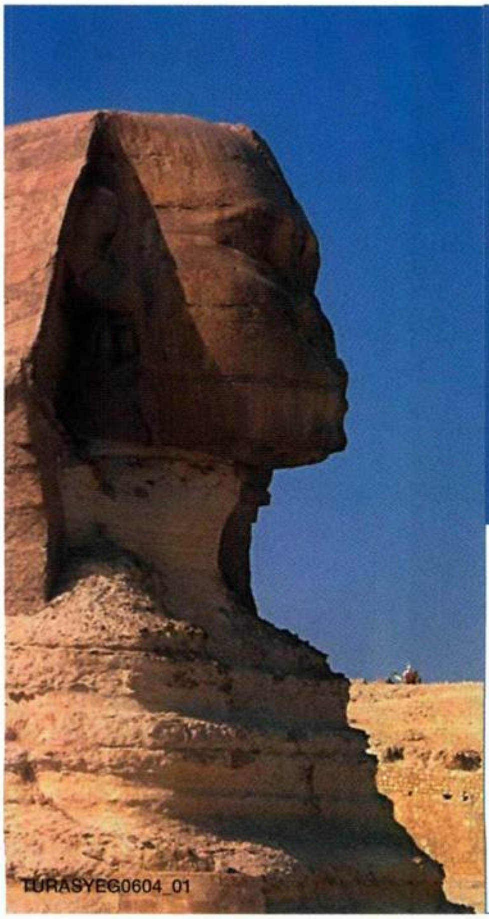

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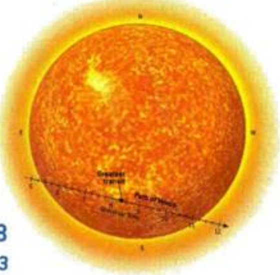
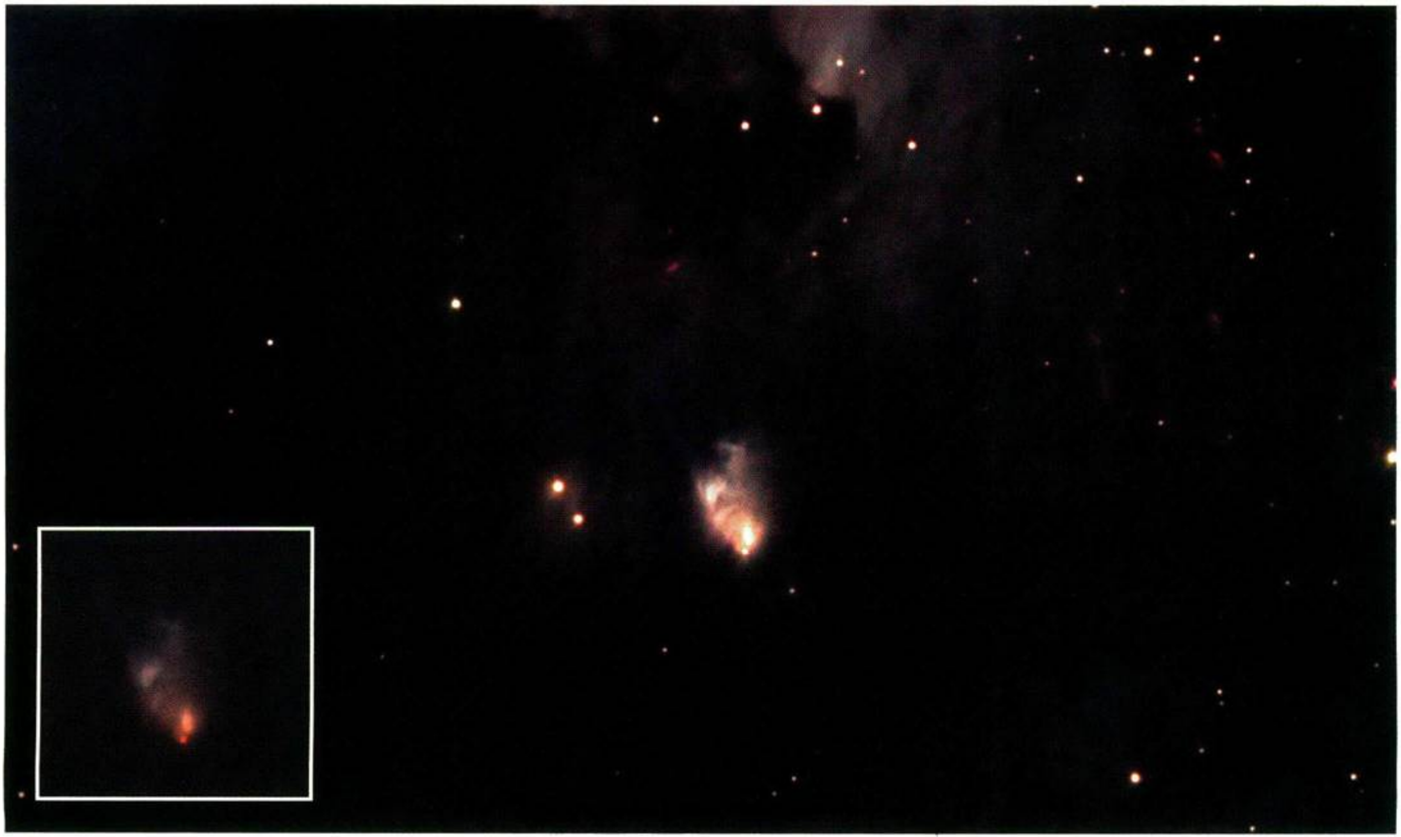


Reader gallery

Readers share their images...

A brand-new nebula /// Jupiter /// Saturn /// Horsehead and Flame nebulae
Comet 2002 T7 (LINEAR) /// The Moon /// Rosette Nebula /// Flaming Star Nebula



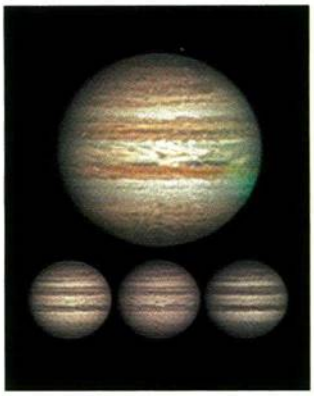
A STAR IN OUTBURST

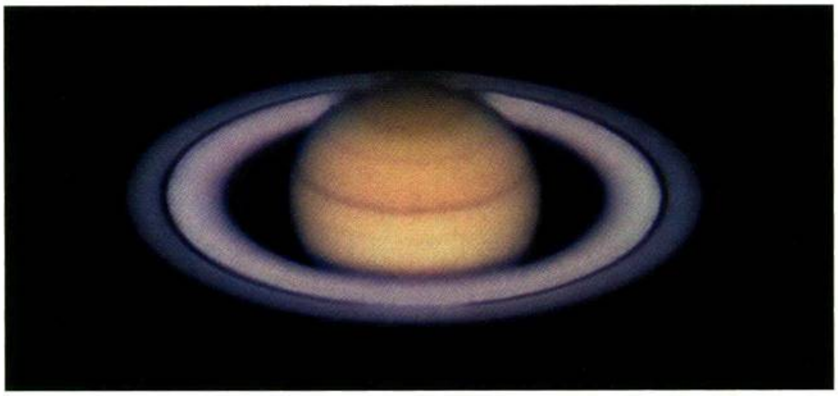
"McNeil's" Nebula

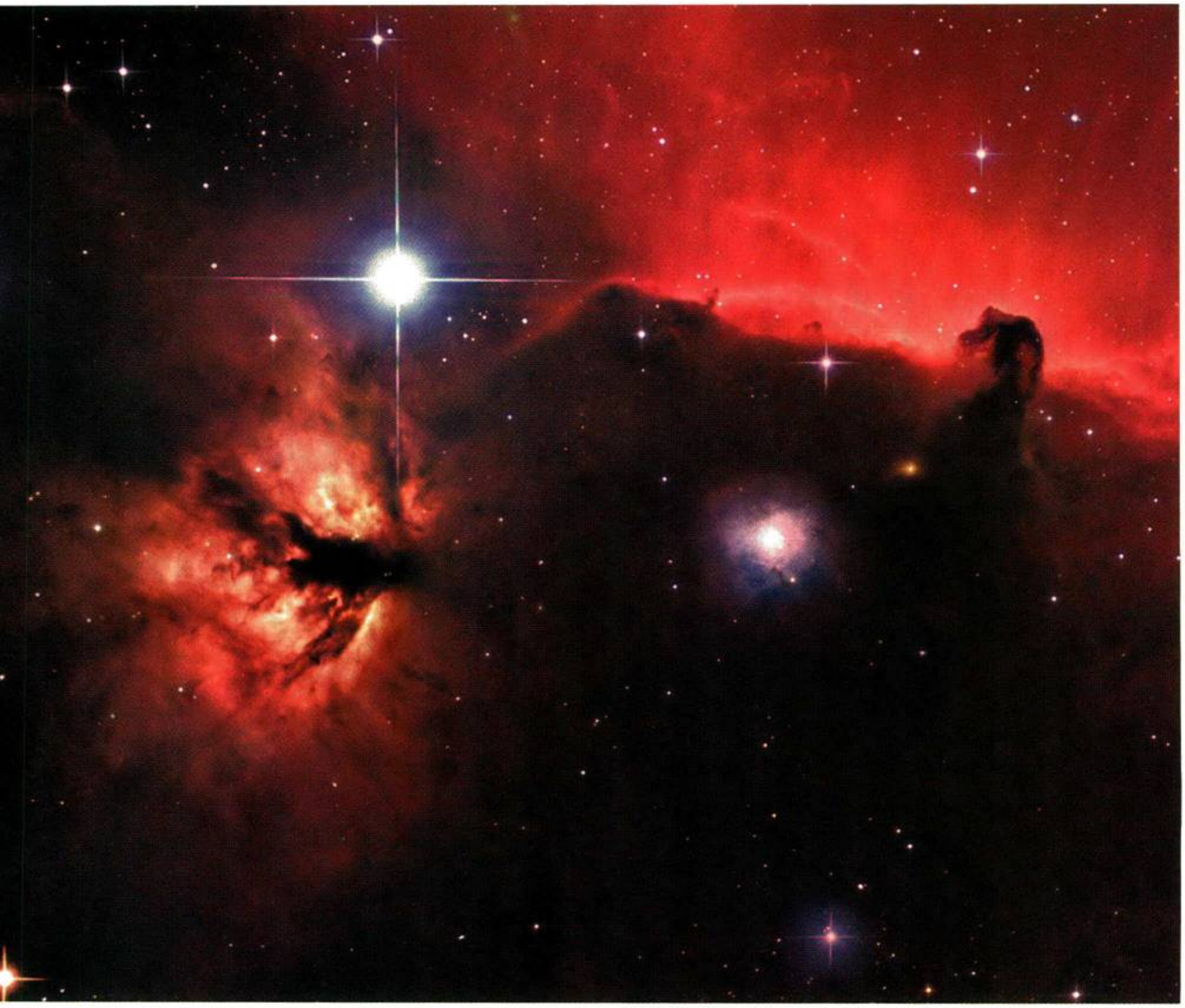
On January 23, 2004, Julian W. (Jay) McNeil of Paducah, Kentucky, imaged M78 in Orion. On examining the image, McNeil discovered a nebulous area he had not seen before. After contacting several professional astronomers, McNeil learned his object was the result of a star erupting and exciting the gas around it. For his discovery image, McNeil used a 3-inch refractor he had just purchased. Within 48 hours, the 8.1-meter (320-inch) Gemini telescope atop Mauna Kea in Hawaii imaged what is now known as McNeil's Nebula. Images of the area taken prior to September 2003 show no object. What a great example of an amateur contributing to astronomy. Congratulations, Jay!

NEW NEBULA IN M78 [20-inch RC Optical Systems Ritchey-Chrétien reflector at f/8.4, SBIG ST-10XME CCD camera, LRGB image with exposures of 90, 15, 15, and 15 minutes, respectively, taken February 13, 2004] *Inset,* **TRUE-COLOR IMAGE OF THE STAR AND NEBULA** [Same data as above minus the L exposure] /// **ADAM BLOCK**

Send your photos to: ASTRONOMY reader gallery, P.O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.





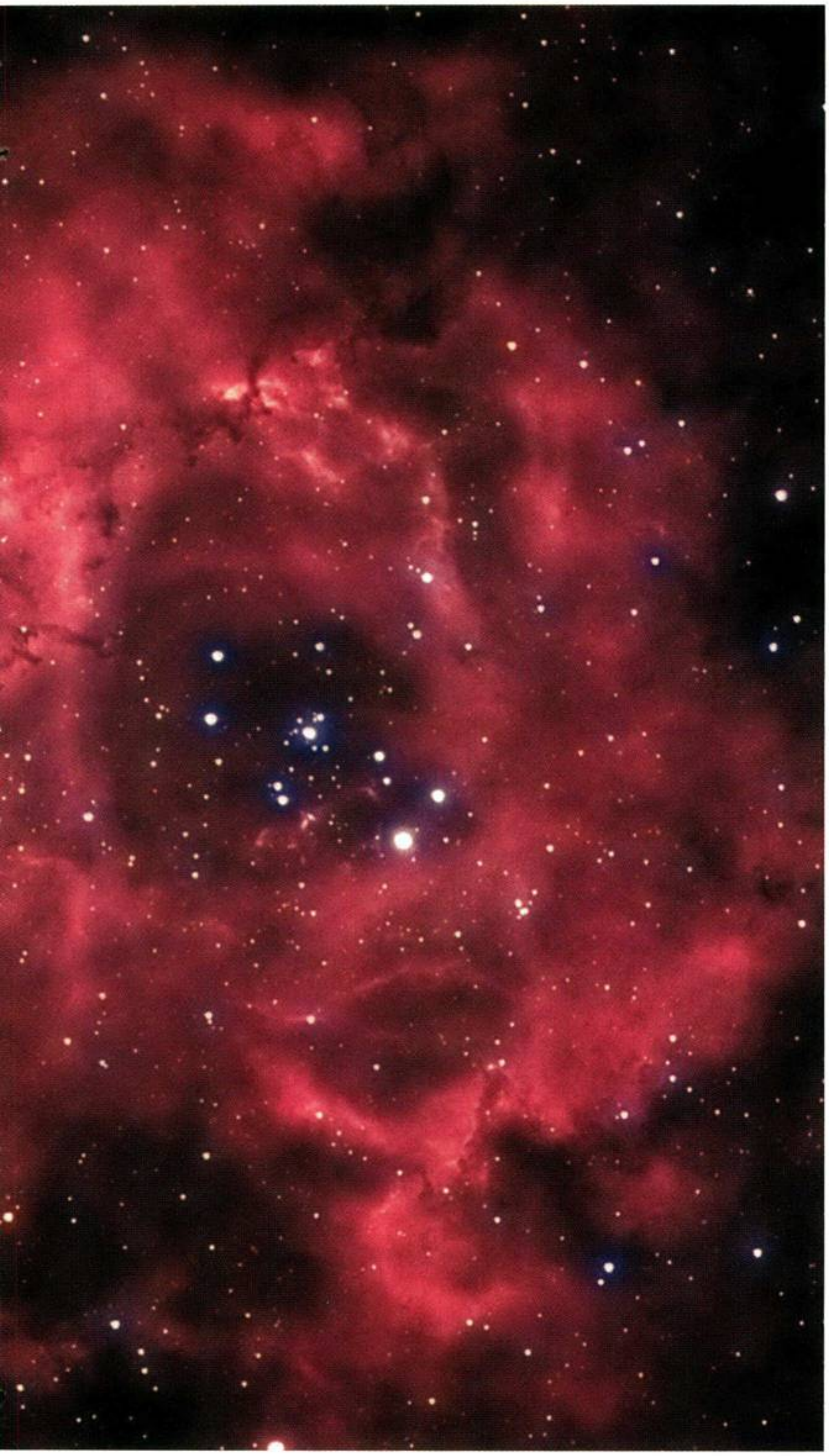


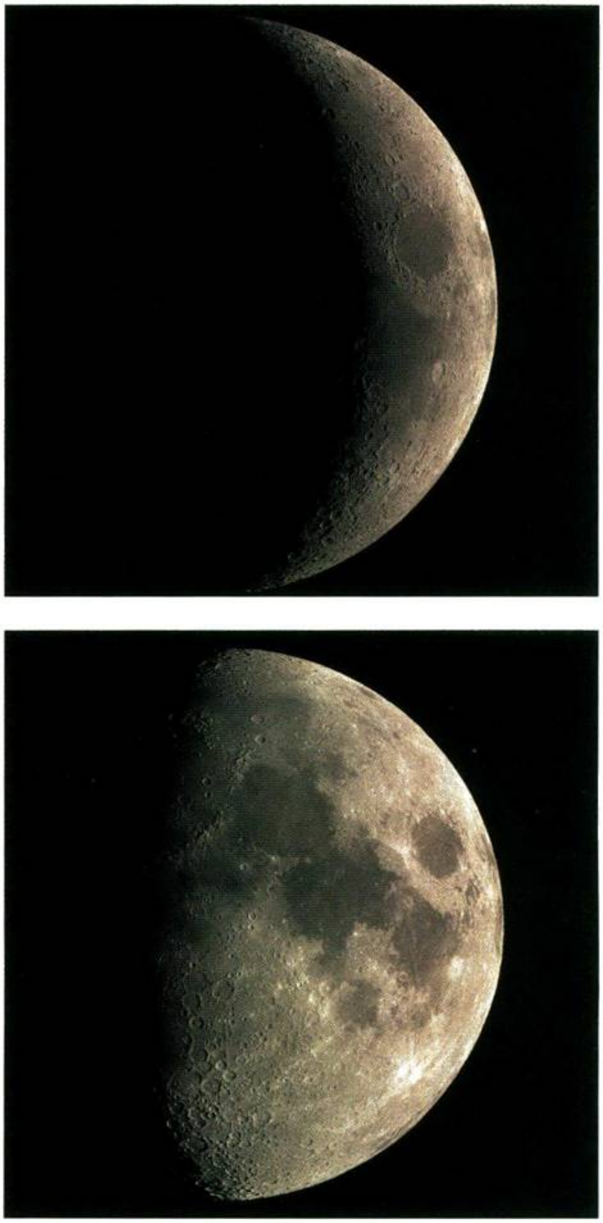
Top left, **JUPITER** [14-inch Celestron Schmidt-Cassegrain telescope at f/27, SBIG ST-5 CCD camera, taken January 11, 2004, at 9h00m UT from Houston, Texas] /// **ED GRAFTON**

Top right, **SATURN** [11-inch Celestron Schmidt-Cassegrain telescope, 1/10-second afocal exposure with an Olympus C4000Z digital camera at full digital zoom and a 10mm Tele Vue Radian eyepiece, taken December 23, 2003, at 10:30 P.M. EST from Tierra Verde, Florida] /// **JOSE SURO**

Bottom, **THE HORSEHEAD AND FLAME NEBULAE IN ORION** [12.5-inch Ritchey-Chrétien reflector at f/9 and a 6-inch Astro-Physics AP155 refractor at f/7 and SBIG STL-11000M and ST-10XME CCD cameras; 12-hour total exposure, taken from Avon, Connecticut] /// **ROBERT GENDLER**

Below. **COMET 2002 T7 (LINEAR)** (12-inch Ritchey-Chrétien reflector, SBIG ST-8E CCD camera, LRGB image with exposures of 5, 3, 3, and 3 minutes, respectively, taken from Cloudcroft, New Mexico, via remote web operation from Dayton, Ohio, on December 27, 2003) /// **JOHN CHUMACK** *Below right.* **COMET 2002 T7 (LINEAR)** (4-inch Takahashi FSQ106 apochromatic refractor, SBIG ST-2000 CCD camera, LRGB image with exposures of 4, 2, 2, and 2 minutes, respectively, taken January 20, 2004, at 1h30m UT from Van Buren, Arkansas) /// **MIKE HOLLOWAY**

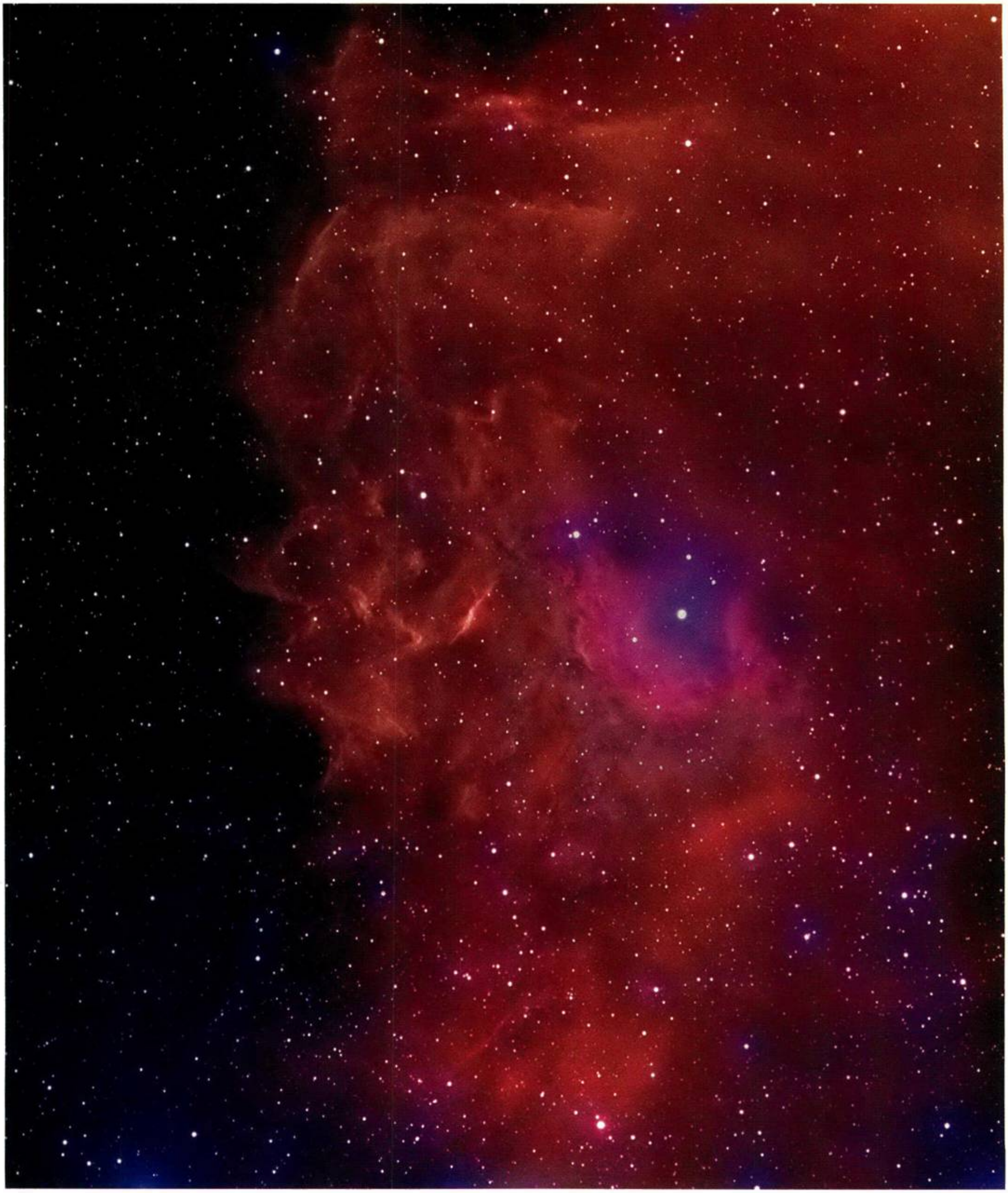




Above. **THE ROSETTE NEBULA (NGC 2237)** (4-inch Takahashi FSQ106 apochromatic refractor, SBIG ST-10XME CCD camera, hydrogen-alpha–RGB image with exposures of 120, 50, 50, and 60 minutes, respectively, taken January 24, 2004, from Mont-Tremblant, Quebec, Canada) /// **REMI LACASSE**

Center and bottom right. **THE MOON, AGES 4 AND 8 DAYS** (8-inch Celestron Schmidt-Cassegrain telescope at f/10, SBIG ST-7E CCD camera, mosaic of 9 frames [center] and 17 frames [bottom], each frame an exposure of 110 milliseconds, taken December 27 and 31, 2003, from Gastonia, North Carolina) /// **FRANK BARRETT**

THE FLAMING STAR NEBULA (IC 405) (4-inch Takahashi FSQ apochromatic refractor at f/5.3, SBIG ST-10XME CCD camera, eight 30-minute exposures through a hydrogen-alpha filter combined with three each of red, green, and blue exposures of 10, 10, and 16 minutes, respectively, taken December 1, 2003, from Oceanside, California) /// **DANIEL B. PHILLIPS**



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